

FORM T-1390
(REV 12-29-99)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371FILED: NOVEMBER 20, 2000
501.39293X00

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/700874

INTERNATIONAL APPLICATION NO.

PCT/JP98/02176

INTERNATIONAL FILING DATE

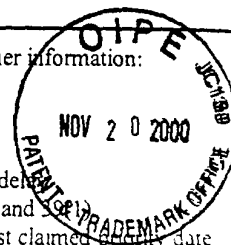
18 May 1998 (18.05.98)

PRIORITY DATE CLAIMED

TITLE OF INVENTION DISK ARRAY CONTROLLER

APPLICANT(S) FOR DO/EO/US FUJIMOTO, Kazuhisa; FUJIBAYASHI, Akira and MINOWA, Nobuyuki

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:



1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than defer examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 34.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
- ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
- ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
- ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
- ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
- ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☒ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

International Publication No. WO99/60471

International Search Report W/Out References

International Preliminary Examination Report

Amendments Under Article 34

Figures 1-83

Credit Card Payment Form

09/700874

INTERNATIONAL APPLICATION NO.
PCT/JP98/02176ATTORNEY'S DOCKET NUMBER
501.39293X0017. ☒ The following fees are submitted:**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :**

Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO \$970.00

International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO \$840.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but
international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$690.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)
but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$670.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)
and all claims satisfied provisions of PCT Article 33(1)-(4) \$96.00

ENTER APPROPRIATE BASIC FEE AMOUNT =**CALCULATIONS** PTO USE ONLY

\$ 860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(e)).

\$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	42 - 20 =	22	X \$18.00
Independent claims	15 - 3 =	12	X \$78.00

\$ 396.00

\$ 960.00

MULTIPLE DEPENDENT CLAIM(S) (if applicable)

+ \$260.00

\$ 0.00

TOTAL OF ABOVE CALCULATIONS =

\$ 2,216.00

Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement
must also be filed (Note 37 CFR 1.9, 1.27, 1.28).

\$

0.00

SUBTOTAL =

\$ 2,216.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(f)).

\$

+

TOTAL NATIONAL FEE =

\$ 2,216.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property

\$

+

0.00

TOTAL FEES ENCLOSED =

\$ 2,216.00

Amount to be
refunded: \$

charged: \$

a. ☒ Credit Card Pymt Form
A. in the amount of \$2,216.00 to cover the above fees is enclosed.b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 01-2135. A duplicate copy of this sheet is enclosed.**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Carl I. Brundidge
ANTONELLI, TERRY, STOUT & KRAUS
1300 NORTH SEVENTEETH STREET
SUITE 1800
ARLINGTON, VA 22204

SIGNATURE

Carl I. Brundidge

NAME

29,621

REGISTRATION NUMBER

~~83~~ 83/PR+9

09/700874

-1-

526 Rec'd PGT/PTO 20 NOV 2000

SPECIFICATION

DISK ARRAY CONTROLLER

TECHNICAL FIELD

This invention relates to a controller for a disk array device which divides data and stores it in plural magnetic disk drives.

BACKGROUND ART

The I/O performance of subsystems which use magnetic disk drives as secondary memories is lower than that of computer main memories by three or four digits. Efforts to minimize this performance discrepancy or improve the I/O performance of subsystems have been made by many people. As one method for improving the I/O performance of subsystems, what is called a disk array, in which a subsystem is composed of plural magnetic disk drives and data is divided and stored in the magnetic disk drives, has been known.

In one example of the prior art, as shown in Fig.2, a disk array device has the following: plural channel interface units 111 for data transmission between a host computer 101 and a disk array controller 5; plural disk interface units 112 for data transmission between magnetic disk drives 120 and the disk array controller 5; a cache memory unit 115

which temporarily stores data to be recorded in the magnetic disk drives 120; and a shared memory unit 114 which stores control data for the cache memory unit 115 and the disk array controller 5, where the cache memory unit 115 and the shared memory unit 114 are accessible from all the channel interface units 111 and all the disk interface units 112. In this conventional system, each of the channel interface units 111 and the disk interface units 112 is connected to the shared memory unit 114 or to the cache memory unit 115.

In another example of the prior art, as shown in Fig.3, a disk array device has the following: plural channel interface units 111 for data transmission between a host computer 101 and a disk array controller 6; plural disk interface units 112 for data transmission between magnetic disk drives 120 and a disk array controller 6; cache memory units 115 which temporarily store data to be recorded in the magnetic disk drives 120; and shared memory units 114 which store control data for the cache memory units 115 and the disk array controller 6, where each of the channel interface units 111 and the disk interface units 112 is connected to the shared memory units 114 through a shared bus 130 and each of the channel interface units 111 and the disk interface units 112 is connected with the cache memory units 115 through a shared bus 130.

DISCLOSURE OF THE INVENTION

Large scale memory systems which are used for data management of main computer systems in large scale companies such as banks, securities companies and telephone companies are required to run around the clock uninterruptedly all the year round. In addition, with the recent growing demand for open-ended systems, scalability of performance and capacity is anticipated to support small to large scale systems.

However, in the prior art shown in Figs.2 and 3, the internal buses which connect each of the channel interface units 111 and disk interface units 112 to the shared memory unit 114 or to the cache memory unit 115 are mounted on one platter (backplane), and channel interface packages and disk interface packages are mounted on the same platter. Due to this structure, in the case of a fault in the internal buses, the platter itself had to be replaced, which means that the whole system had to be stopped.

Besides, since the internal buses are mounted on the platter, their performance is fixed. Therefore, the prior art has the following problem: in small scale systems, the cost performance is low because the performance of the internal buses is too high to match that of the channel or disk interface units, while in large scale systems, the

performance of the internal buses is insufficient and cannot be increased.

As there is a drastic decline in the price of large disk array devices in the market, products with higher cost performance are anticipated

A first object of the present invention is to provide a disk array controller which runs around the clock all the year around uninterruptedly without the need for stopping the whole system in the case of a fault or during maintenance. A second object of the present invention is to provide a disk array controller which provides scalability of performance and capacity without an unfavorable influence on the cost performance.

The above-mentioned objects can be achieved by a disk array controller which has the following: an interface unit platter on which channel interface units connected with the host computer and disk interface units connected with disk drives are mounted; a memory platter on which a shared memory unit for storing control data is mounted; and cables which connect the interface platter and the memory platter.

Also, the above-mentioned objects can be achieved by a disk array controller which has the following: plural platters on each of which channel interface units connected with the host computer, disk interface units connected with disk drives and a shared memory unit for storing control data

are mounted; and cables which interconnect the plural platters.

Furthermore, the above-mentioned objects can be achieved by a disk array controller which has the following: an interface platter on which channel interface units connected with the host computer, disk interface units connected with disk drives, shared buses which connect the channel interface units and disk interface units, and shared bus interconnect controllers connected with the shared buses to control requests from the channel interface units and the disk interface units, are mounted; a memory platter on which shared memory units for storing control data are mounted; and cables which connect the interface platter and the memory platter.

The above-mentioned disk array controller according to this invention uses expensive cables. Further, data transmission at high frequencies by cables is likely to cause noise. Therefore, a further object of this invention is to shorten the cable length in the disk array controller according to this invention which is placed in the rack, as far as possible.

The above-said further object of the present invention can be achieved by a disk array controller which has the following: an interface platter on which channel interface units connected with the host computer, and disk

2025 RELEASE UNDER E.O. 14176

interface units connected with disk drives are mounted; and a memory platter on which shared memory units for storing control data are mounted, where the orientation of the mounted interface platter is different from that of the mounted memory platter.

Also the above-said further object of the present invention can be achieved by a disk array controller which has the following: plural interface platters on each of which channel interface units connected with the host computer, and disk interface units connected with disk drives are mounted; and a memory platter on which shared memory units for storing control data are mounted, where the memory platter is located between the plural interface platters.

Also, the above-said further object can be achieved by a disk array controller which has plural platters on each of which channel interface units connected with the host computer, disk interface units connected with disk drives, and a shared memory unit for storing control data are mounted, where one of the plural platters is located above another of them.

Other solutions for the above-mentioned objects and further object will be discussed in the section "BEST MODE FOR CARRYING OUT THE INVENTION."

BRIEF DESCRIPTION OF DRAWINGS

Fig.1 shows a configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.2 shows a configuration of a conventional disk array controller.

Fig.3 shows a configuration of a conventional disk array controller.

Fig.4 shows a configuration of a disk array controller according to this invention.

Fig.5 shows another configuration of a disk array controller according to this invention.

Fig.6 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.7 shows another configuration of a disk array controller according to this invention.

Fig.8 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.9 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.10 shows another configuration of a disk array controller according to this invention.

Fig.11 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.12 shows another configuration of a disk array controller according to this invention.

Fig.13 shows another configuration of a disk array controller according to this invention.

Fig.14 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.15 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.16 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.17 shows another configuration of a disk array controller according to this invention.

Fig.18 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.19 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.20 shows another configuration of a disk array controller according to this invention.

Fig.21 shows another configuration of a disk array controller according to this invention.

Fig.22 shows another configuration of a disk array controller according to this invention.

Fig.23 shows another configuration of a disk array controller according to this invention.

Fig.24 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

09700974.040004

Fig.25 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.26 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.27 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.28 shows another configuration of a disk array controller according to this invention.

Fig.29 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.30 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.31 shows another configuration of a disk array controller according to this invention.

Fig.32 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.33 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.34 shows another configuration of a disk array controller according to this invention.

Fig.35 shows another configuration of a disk array controller according to this invention.

Fig.36 shows another configuration of a disk array controller according to this invention.

Fig.37 shows another configuration of a disk array controller according to this invention.

Fig.38 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.39 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.40 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.41 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.42 shows another configuration of a disk array controller according to this invention.

Fig.43 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.44 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.45 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.46 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.47 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.48 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.49 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.50 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.51 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.52 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.53 shows another configuration of a disk array controller according to this invention.

Fig.54 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.55 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.56 shows another configuration of a disk array controller according to this invention.

Fig.57 shows another configuration of a disk array controller according to this invention.

Fig.58 shows another configuration of a disk array controller according to this invention.

Fig.59 shows another configuration of a disk array controller according to this invention.

Fig.60 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.61 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.62 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.63 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.64 shows another configuration of a disk array controller according to this invention.

Fig.65 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.66 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.67 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.68 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.69 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.70 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.71 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.72 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.73 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.74 shows another configuration in the rack-mounted form of a disk array controller according to this invention.

Fig.75 shows one form of implementation of platters in a disk array controller according to this invention.

Fig.76 shows another form of implementation of platters in a disk array controller according to this invention.

Fig.77 shows a rack housing a disk array controller according to this invention.

Fig.78 shows another type of rack housing a disk array controller according to this invention.

Fig.79 shows another type of rack housing a disk array controller according to this invention.

Fig.80 shows connections between platters in a disk array controller according to this invention.

Fig.81 shows how interface platters in a disk array controller according to this invention are mounted.

Fig.82 shows how memory platters in a disk array controller according to this invention are mounted. and

Fig.83 shows how power supplies of a disk array controller according to this invention are mounted.

BEST MODE FOR CARRYING OUT THE INVENTION

The best mode for carrying out this invention is explained next using various embodiments.

[Embodiment 1]

Figs. 1 and 4 show one embodiment of the invention.

Fig.4 shows the configuration of a disk array controller according to the invention. The disk array controller 1 has channel interface units 111, disk interface units 112, shared memory units 114 and access paths 0 (135).

The channel interface units 111 each have at least one interface with the host computer, at least one microprocessor, at least one (two, in this embodiment) access circuit to the shared memory units 114, and at least one (two, in this embodiment) access path interfaces to the shared memory units 114 (these are not shown here) to enable data transmission between the host computer 101 and the shared memory units 114.

The disk interface units 112 each have at least one interface with plural magnetic disk drives 120, at least one microprocessor, at least one (two, in this embodiment) access circuit to the shared memory units 114, and at least one (two, in this embodiment) access path interface with the shared memory units 114 (these are not shown here) to enable data transmission between the plural magnetic disk drives 120 and the shared memory units 114.

The shared memory units 114 each have a memory for storing data to be recorded in the magnetic disk drives 120, control data for that data and control data for the disk array controller 1, and at least one (eight, in this embodiment) access path interfaces (these are not shown here) to the interface units.

In this embodiment, two channel interface units 111 and two disk interface units 112 constitute one group, which is called an I/F group 160. In this embodiment, the disk array controller 1 has two I/F groups.

Here, the number of I/F groups 160 is not limited as above. The number of I/F groups depends on the number of access paths to the shared memory units, management unit for maintenance (the number of channel and disk interface units subjected to each maintenance service), and other factors. One possibility is that the minimum disk array controller configuration corresponds to one I/F group.

Fig.1 illustrates the configuration of the disk array controller 1 in the rack-mounted form. The channel interface units 111, disk interface units 112 and shared memory units 114 shown in Fig.4 are separately packaged in channel interface packages (PK) 11, disk interface packages (PK) 12 and shared memory packages (PK), respectively. The channel interface packages 11 and disk interface packages 12 which constitute one I/F group 160, are mounted on one interface

platter (P/L) 2, and the two shared memory packages 14 are mounted on a memory platter (P/L) 3 different from the interface platters 2. Each interface platter 2 and the memory platter 3 are connected by a cable 4. The cable 4 is a cable for access path 0 (135) which connects the channel interface units 111 or disk interface units 112 with the shared memory units 114.

The channel interface packages 11, disk interface packages 12, and shared memory packages 14 may be all mounted on different platters.

As described above, when a certain number of interface packages are mounted on one interface platter, in case of a fault in a platter, it is only necessary to stop the parts for which the packages mounted on that platter are responsible, instead of stopping the entire system. Also, since the cable 4 is used for the access paths 0 (135), the number of access paths 0 (135) can be easily increased or decreased as the number of interface platters 2 bearing interface packages increases or decreases, so that scalability of access path 0 performance can be assured. Therefore, the performance and capacity can be flexibly varied depending on the scale of the system, without any deterioration in cost performance. This also implies that a disk array controller product can be supplied at a reasonable price which suits the scale of the system.

[Embodiment 2]

Figs.31 and 32 show another embodiment of this invention. Its difference from embodiment 1 is that the two shared memory units 114 in Fig.4 are interconnected via access path 2 (139) to make a dual system, as shown in Fig.31.

Fig.32 illustrates the configuration of the disk array controller 1 in Fig.31 in the rack-mounted form. Two shared memory units 114 are separately packaged in two shared memory packages (PK) 14, which are mounted on different memory platters 3. The memory platters 3 are interconnected by cable 2 (4-9) and one interface platter 2 and each of the two memory platters 3 are connected by cable 4. The cable 2 is a cable for access path 2 (139) as shown in Fig.31.

This configuration not only produces the same effects as those of embodiment 1 but also a further effect: Thanks to the dual system of shared memory units 114, even if one shared memory package 14 or memory platter 3 fails, the system can be operated using the shared memory package 14 mounted on the other memory platter 3. Therefore, it is possible to replace the defective shared memory package 14 or memory platter 3, without stopping the system.

In this embodiment, the shared memory units 114 are interconnected via access path 2 (139) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared

memory units 114 from the channel interface units 111 or disk interface units 112. In this case, it is unnecessary to interconnect the shared memory units 114 via access path 2 (139). However, if they are interconnected via access path 2 (139), the data in the two shared memory units 114 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

[Embodiment 3]

Fig.45 shows another embodiment of the invention. Like embodiment 2, this embodiment uses two shared memory units 114 which make up a dual system. Two shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on one memory platter 3. This memory platter 3 is divided into two areas by a power supply boundary 300. Power is separately supplied from independent power supplies to the two areas. Each of the areas bears one shared memory package 14. One interface platter 2 and the two areas of the memory platter 3 are connected by cables 4.

This configuration not only produces the same effects as those of embodiment 1 but also a further effect: even if a fault occurs in the shared memory package 14 in one of the areas into which the memory platter 3 is divided by the power supply boundary 300, the system can be operated using the shared memory package 14 mounted on the other area.

Therefore, it is possible to replace the defective shared memory package 14, without stopping the system.

[Embodiment 4]

Figs.17 and 18 show another embodiment of the invention. Its difference from embodiment 1 is that as shown in Fig.17, the cache memory units 115 for storing data to be recorded in magnetic disk drives 120, and the shared memory units 114 for storing control data for the cache memory units 115 and the disk array controller 1 are physically divided, and access paths a (137) to the shared memory units 114, and access paths b (138) to the cache memory units 115 are independent of each other.

Fig.18 illustrates the configuration of the disk array controller 1 in Fig.17 in the rack-mounted form. The cache memory units 115 and the shared memory units 114 are separately packaged in cache memory packages 15 and shared memory packages 14, respectively, which are mounted on the memory platter 3. In place of the cable 4 which connects each interface platter 2 and the memory platter 3 as shown in Fig.1, cables a (4-3) for access paths a (137) to the shared memory units 114 and cables b (4-4) for access paths b (138) to the cache memory units 115 are used.

The shared memory packages 14 and the cache memory packages 15 may be mounted on different platters.

This configuration not only produces the same effects as those of embodiment 1 but also a further effect: Since access paths from the channel interface packages 11 and the disk interface packages 12 to the cache memory packages 15 or the shared memory packages 14 can be made physically independent, it is possible to distinguish between faults related to access to the cache memory units 115 (faults in the cache memory units 115 or paths or others for access to them) and faults related to access to the shared memory units 114 (faults in the shared memory units 114 or paths or others for access to them) so that defective parts can be independently repaired without affecting other parts.

[Embodiment 5]

Figs.53 and 54 show another embodiment of this invention. Its difference from embodiment 4 is that two shared memory units 114 are interconnected via access path a2 (140) and two cache memory units 115 are interconnected via access path b2 (141) to make a dual system, as shown in Fig.53.

Fig.54 illustrates the configuration of the disk array controller 1 in Fig.53 in the rack-mounted form. Two shared memory units 114 and two cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, and one shared memory package and one cache memory package, which constitute one set, are mounted on one memory platter 3, with the two memory

platters 3 being interconnected by cable a2 (4-10) and cable b2 (4-11). One interface platter 2 is connected to two memory platters 3 by cable a (4-3) and cable b (4-4). Cable a2 (4-10) and cable b2 (4-11) are cables for access path a2 (140) and access path b2 (141), respectively.

This configuration not only produces the same effects as those of embodiment 4 but also a further effect: Even if a fault occurs in one shared memory package 14, cache memory package 15 or memory platter 3, the system can be operated using the shared memory package 14 or cache memory package 15 mounted on the other memory platter 3. Therefore, it is possible to replace the defective shared memory package 14, cache memory package 15 or memory platter 3, without stopping the system.

In this embodiment, the shared memory units 114 are interconnected via access path a2 (140) and the cache memory units 115 are interconnected via access path b2 (141); however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 or both the two cache memory units 115 from the channel interface units 111 or the disk interface units 112. In this case, it is unnecessary to interconnect the shared memory units 114 or the cache memory units via access path a2 (140) or access path b2 (141). However, if they are interconnected via access path a2 (140) or access path b2

00700674.040004

(141), the data in the two shared memory units 114 or the two cache memory units 115 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

[Embodiment 6]

Fig.67 shows another embodiment of the invention. As shown in Fig.67, in this embodiment, two shared memory units 114 and two cache memory units 115 are packaged in shared memory packages 14 and cache memory packages 15, respectively, which are mounted on one memory platter 3 which is divided into two areas by a power supply boundary 300 as in embodiment 3. Each of the areas bears one shared memory package 14 and one cache memory package 15. One interface platter 2 is connected to one of the two areas of the memory platter 3 by cables a (4-3) and to the other by cables b (4-4). This embodiment thus provides a dual system which consists of two shared memory units 114 and two cache memory units 115.

This configuration not only produces the same effects as those of embodiment 4 but also a further effect: Even if a fault occurs in the shared memory package 14 or cache memory package 15 in one of the areas into which the memory platter 3 is divided by the power supply boundary 300, the system can be operated using the shared memory package 14 or cache memory package 15 in the other area of the memory platter

3. Therefore, it is possible to replace the shared memory package 14 or cache memory package 15 in the area where the fault has occurred, without stopping the system.

[Embodiment 7]

Fig. 5 shows another embodiment of the invention.

The disk array controller 1 shown in Fig.5 has the following: channel interface units 111; disk interface units 112; two shared buses 0 (31) which connect them; shared memory units 114; two shared buses 1 (32) which interconnect the shared memory units; shared bus interconnect controllers 140 which connect the shared buses 0 (31) and shared buses 1 (32); and access paths 0 (135).

Each channel interface unit 111 has at least one interface with the host computer, at least one microprocessor, at least one (two, in this embodiment) access circuit to the shared memory unit 114, and at least one (two, in this embodiment) interface with the shared buses 0 (31) (these are not shown here) to enable data transmission between the host computer 101 and the shared memory units 114.

Each disk interface unit 112 has at least one interface with plural magnetic disk drives 120, at least one microprocessor, at least one (two, in this embodiment) access circuit to the shared memory units 114, and at least one (two, in this embodiment) interface with the shared

buses 0 (31) (these are not shown here) to enable data transmission between the plural magnetic disk drives 120 and shared memory units 114.

Each shared memory unit 114 has a memory for storing data to be recorded in the magnetic disk drives 120, control data for that data and control data for the disk array controller, and at least one (two, in this embodiment) interface with shared buses 1 (32) (these are not shown here).

One shared bus is connected with one shared bus interconnect controller 140. The shared bus interconnect controllers 140 connected with the shared buses 1 (32) each have two access paths 0 (135) from two shared bus interconnect controllers 140 which belong to different I/F groups 160.

For access from the channel interface units 111 or disk interface units 112 to the shared memory units 114, the SM access circuit (not shown here) inside each channel interface unit 111 or disk interface unit 112 first obtains the right to use the shared buses 0 (31) and then accesses the shared bus interconnect controller 140 connected with the shared buses 0 (31), and issues a request for access to the shared buses 1 (32). The shared bus interconnect controller 140 sends the access request to the shared bus interconnect controller 140 connected with the shared buses 1 (32). If the shared bus interconnect controller 140

connected with the shared buses 1 (32) receives access requests from two different shared bus interconnect controllers 140 connected with it, it selects one of them by arbitration and obtains the right to use the shared buses 1 (32). After obtainment of the right, the shared bus interconnect controller connected with the shared buses 1 (32) sends the access request to the shared memory units.

In this embodiment, two channel interface units 111, two disk interface units 112 and two shared bus interconnect controllers 140 constitute one group, which is hereinafter called an I/F group 160. In this embodiment, the disk array controller 1 has two I/F groups.

Here, the number of I/F groups 160 is not limited as above. The number of I/F groups depends on the management unit for maintenance (the number of channel and disk interface units subjected to each maintenance service), and other factors. One possibility is that the minimum disk array controller configuration corresponds to one I/F group. Though this embodiment uses two shared buses 0 (31), it is possible to use only one. However, the use of two shared buses like this makes the access path to the shared memory units 114 redundant, which improves trouble resistance.

The configuration of the disk array controller 1 in Fig.5 in the rack-mounted form is basically the same as the configuration of embodiment 1 shown in Fig.1. The difference

from embodiment 1 is that shared buses 0 (31) are wired on interface platters 2 and shared bus interconnect controllers 140 are directly mounted there, and that shared buses 1 (32) are wired on one memory platter and shared bus interconnect controllers 140 are directly mounted there.

The advantage of this configuration is as follows. The use of cables as access paths would be more costly than when access paths are directly mounted on a platter. Further, data transmission at high frequencies by several cables could cause noise unless the cable length is equalized with high accuracy. It is more advantageous in terms of scalability to use cables for all access paths between the channel interface packages 11, disk interface packages 12 and shared memory package 14 as in the disk array controller of embodiment 1. However, for the above-mentioned reason, the use of many cables may be disadvantageous in terms of cost and implementation efficiency. Therefore, in this embodiment the number of cables used is decreased in comparison with the disk array controller of embodiment 1 by wiring shared buses 0 (31) on interface platters 2 and directly mounting shared bus interconnect controllers 140 thereon, and wiring shared buses 1 (32) on one memory platter and directly mounting shared bus interconnect controllers 140 thereon. This realizes a disk array controller which has an advantage over the prior art in terms of scalability and

over the disk array controller of embodiment 1 in terms of cost and implementation efficiency.

In addition, since this embodiment uses a dual system consisting of two shared buses 0 (31), two shared buses 1 (32) and shared bus interconnect controllers 140 connected with them, one channel interface unit 111 or disk interface unit 112 has two access routes to one shared memory unit 114. Therefore, in this embodiment, one cable 4 as shown in Fig.1 is replaced by two cables, each of which is allocated to one of the two access paths 0 (135). Thanks to this dual system, if one of the two access paths 0 (135) fails, the other access path 0 (135) can be used, permitting the system to operate uninterruptedly. During operation of the system, the cable 4 for the defective access path 0 (135) can be replaced.

[Embodiment 8]

Fig.34 shows another embodiment of this invention. In the disk array controller 1 as shown in Fig.34, two shared memory units 114 connected with two shared buses 1 (32) and two shared bus interconnect controllers 140 constitute one group. Two such groups make up shared memory. The two shared memory units in one group and those in the other group are connected via access paths 2 (139) to make a dual system. In short, this embodiment doubles the group of shared memory units 114 as shown in Fig.5 for embodiment 7.

The configuration of the disk array controller 1 in Fig.34 in the rack-mounted form is the same as the configuration shown in Fig.32 for embodiment 2, except that the four shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on two different memory platters 3 group by group. Therefore, in this embodiment, since one such group contains two shared memory units 114, one memory platter 3 bears two shared memory packages 14 (Fig.32 shows only one shared memory package 14 on each platter). In this respect, this embodiment is different from embodiment 2. Another difference from embodiment 2 is that shared buses 1 (32) are wired on the memory platters 3 and two shared bus interconnect controllers are directly mounted thereon (these are not shown here).

The above-mentioned configuration produces the same effects as those of embodiments 2 and 7.

In this embodiment, the shared memory units 114 are interconnected via access paths 2 (139) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 from the channel interface units 111 or disk interface units 112. In this case, it is unnecessary to interconnect the shared memory units 114 via access paths 2 (139). However, if they are interconnected via access

paths 2 (139), the data in the two shared memory units 114 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

The above-said groups of shared memory units 114 may be mounted in the same way as shown in Fig.45 for embodiment 3. In other words, each of the above groups of shared memory units 114 is mounted on each of the two areas of one memory platter 3 divided by a power supply boundary 300, to which power is supplied from separate power supplies.

Thanks to this configuration, even if a fault occurs in a shared memory package 14 in one of the areas into which the memory platter 3 is divided by the power supply boundary 300, the system can be operated using the shared memory packages 14 mounted on the other area, so the defective shared memory package 14 can be replaced without stopping the system.

[Embodiment 9]

Fig.20 shows another embodiment of this invention. According to this embodiment, the cache memory units and shared memory units in the disk array controller shown in Fig.5 for embodiment 7 are physically divided as described for embodiment 4. Also, in this embodiment, the shared buses 0 (31) in Fig.5 are divided into shared buses b0 (35) for transmitting data from the magnetic disk drives 120 and shared buses a0 (33) for transmitting control data for the

cache memory units 115 and disk array controller 1, and the channel interface units 111 and disk interface units 112 are connected to both the shared buses a0 (33) and shared buses b0 (35). Further, the shared buses 1 (32) in Fig.5 are divided into shared buses b1 (36) for transmitting data from the magnetic disk drives 120 and shared buses a1 (34) for transmitting control data for the cache memory units 115 and disk array controller 1, and the cache memory units 115 and shared memory units 114 are connected to the shared buses b1 (36) and shared buses a1 (34), respectively. Connections are made between the shared buses a0 (33) and shared buses a1 (34), and between the shared buses b0 (35) and the shared buses b1 (36) through shared bus interconnect controllers 140, via access paths a (137) and access paths b (138), respectively.

The configuration of the disk array controller 1 in Fig.20 in the rack-mounted form is the same as the one shown in Fig.18 for embodiment 4, except that the two cache memory units 115 and two shared memory units 114 in Fig.20 are separately packaged in two separate cache memory packages 15 and two shared memory packages 14, respectively, which are mounted on a memory platter 3. On the memory platter 3, the shared buses a1 (34) and shared buses b1 (36) are wired and the shared bus interconnect controllers 140 are directly mounted thereon (all these are not shown here). On each

interface platter 2, the shared buses a0 (33) and shared buses b0 (35) are wired and the shared bus interconnect controllers 140 are directly mounted thereon (all these are not shown here). The cable which connects each interface platter 2 and memory platter 3 is divided into a cable a (4-3) for access path a (137) to the shared memory units 114 shown in Fig.20 and a cable b (4-4) for access path b (138) to the cache memory units 115 in Fig.20.

This configuration not only produces the same effects as those of embodiment 7 but also a further effect: Since the access paths from the channel interface packages 11 and disk interface packages 12 to the cache memory packages 15 or shared memory packages 14 are physically independent, it is possible to distinguish between faults related to access to the cache memory units 115 (faults in the cache memory units 115 or the shared buses b0 (35), shared buses b1 (36), shared bus interconnect controllers 140, access paths b (138) or others for access to them) and faults related to access to the shared memory units 114 (faults in the shared memory units 114 or the shared buses a0 (33), shared buses a1 (34), shared bus interconnect controllers 140, access paths a (137) or others for access to them) so that defective parts can be independently repaired without affecting other parts.

[Embodiment 10]

Fig.56 shows another embodiment of this invention. As shown in Fig.56, two shared memory units 114 connected with two shared buses a1 (34), and two shared bus interconnect controllers 140, constitute one group; two such groups make up shared memory. The two shared memory units 114 in one such group and those in the other group are connected via access paths a2 (140) to make a dual system. Two cache memory units 115 connected with two shared buses b1 (36), and two shared bus interconnect controllers 140, constitute one group; two such groups make up cache memory. The two cache memory units 115 in one such group and those in the other group are connected via access paths b2 (140) to make a dual system.

In short, this embodiment doubles the group of shared memory units 114 and the group of cache memory units 115 as shown in Fig.20 for embodiment 9.

The configuration of the disk array controller 1 in Fig.56 in the rack-mounted form is the same as the one shown in Fig.54 for embodiment 5, except that the four shared memory units 114 and four cache memory units 115 as shown in Fig.56 are separately mounted in shared memory packages 14 and cache memory packages 15, respectively, and one shared memory group and one cache memory group are mounted on one memory platter 3. On each memory platter 3, shared buses a1 (34) and shared buses b1 (36) are wired and four shared bus interconnect controllers 140 are directly

mounted. On each interface platter 2, shared buses a0 (33) and shared buses b0 (35) are wired and shared bus interconnect controllers 140 are directly mounted (all these are not shown here). Connection between the memory platters 3 is made by cables a2 (4-10) and b2 (4-11). One interface platter 2 is connected with the two memory platters 3 by cables a (4-3) and b (4-4). Cables a2 (4-10) are cables for access paths a2 (140) in Fig.56 and cables b2 (4-11) are ones for access paths b2 (141).

This configuration produces the same effects as those of embodiments 5 and 9.

In this embodiment, the shared memory units 114 are interconnected via access paths a2 (140) and the cache memory units are interconnected via access paths b2 (141) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 or both the two cache memory units 115 from the channel interface units 111 or the disk interface units 112. In this case, it is unnecessary to interconnect the shared memory units 114 or cache memory units 115 via access paths a2 (140) or access paths b2 (141). However, if they are interconnected, the data in the two shared memory units 114 or two cache memory units can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

The groups of shared memory units 114 and the groups of cache memory units 115 may be mounted as shown in Fig.67. Concretely, the shared memory units 114 and cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively. These are mounted on one of the two areas of one memory platter divided by a power supply boundary 300, where power is supplied to each area from a separate power supply. Here, the interface platters 2 are connected to the two areas of the memory platter 3 by cables a (4-3) and b (4-4). In this case, each area of the memory platter 3 bears two shared memory packages 14 and two cache memory packages 15 (though Fig.67 shows only one package of each memory type in each area).

Thanks to this configuration, even if a fault occurs in a shared memory package 14 or cache memory package 15 in one of the areas into which the memory platter 3 is divided by the power supply boundary 300, the system can be operated using the shared memory packages 14 or the cache memory packages 15 mounted on the other area, so the defective shared memory package 14 or cache memory package 15 can be replaced without stopping the system.

[Embodiment 11]

Figs. 6 and 7 show another embodiment of this invention.

Fig.7 illustrates the configuration of a disk array controller according to this embodiment. The disk array controller 1 has channel interface units 111, disk interface units 112, selectors 113, shared memory units 114, access paths 0 (135) and access paths 1 (136).

The channel interface units 111, disk interface units 112, and shared memory units 114 have the same structures as those in embodiment 1.

Each selector unit 113 is connected with a total of four access paths 0 (135) from two channel interface units 111 and two disk interface units 112 on the basis of one path per unit. Also each selector unit 113 is connected with two access paths 1 (36), with each path being connected with one of the two shared memory units 114. One such selector unit 113 and two channel interface units 111 and two disk interface units 112 which are connected with it constitute one group, which is hereinafter called a selector group 150. In this embodiment, the disk array controller 1 has two selector groups 150 and two shared memory units 114. Due to the above-mentioned availability of access paths, each selector unit 113 selects two of the four requests transmitted via the four access paths 0 (135) from the channel interface units 111 and disk interface units 112, where the number of selected requests corresponds to the

number of access paths 1 (136) to the shared memory units 114.

Here, the important thing is that the number of access paths 1 (136) from one selector unit 113 to the shared memory units 114 is smaller than the number of access paths 0 (135) from the channel interface units 111 and disk interface units 112 to one selector unit 113, and that the number of selector units 113 is smaller than the total number of channel interface units and disk interface units 112. This reduces the number of access paths to each shared memory unit 114, which means a decrease in the number of cables used, leading to cost reduction and higher implementation efficiency. In addition, the problem of LSI pin necks and package connector necks in the shared memory units can be resolved.

The number of channel interface units and disk interface units in a selector group 150 depends on the management unit for maintenance (the number of interface units subjected to each maintenance service), and other factors. One possibility is that the minimum disk array controller configuration corresponds to one selector group 150.

Fig.6 illustrates the configuration of the disk array controller 1 in the rack-mounted form.

The channel interface units 111, disk interface units 112, selector units 113 and shared memory units 114 as shown

in Fig.7 are separately packaged in channel interface packages 11, disk interface packages 12, selector packages 13 and shared memory packages 14, respectively. One selector group 150 is mounted on one interface platter 2, and two shared memory packages 14 are mounted on a memory platter 3 different from the interface platters 2. The interface platters 2 and memory platter 3 are connected by cables 1 (4-2). The cables are cables for access paths 1 (136) as shown in Fig.7.

Although the selector units 113 are packaged in selector packages 13 in this example, as shown in Fig.8 they may be mounted on the reverse of the package bearing surface of the interface platters 2 without packaging them in packages (the figure shows the backside). This causes no problem in implementing this embodiment and can reduce the required width of each interface platter by the amount equivalent to the width of the selector package 13, permitting the rack for the disk array controller 1 to be more compact.

This configuration not only produces the same effects as those of embodiment 1 but also a further effect: The use of selector units 113 reduces the number of access paths to the shared memory units 114, which means a decrease in the number of cables used, leading to cost reduction and higher implementation efficiency. In addition, the problem of LSI

pin necks or package connector necks in shared memory units can be resolved.

Variations of this embodiment are introduced next.

Fig.37 shows a dual cache memory system consisting of two shared memory units 114 connected via access path 2 (139) as in embodiment 2. Fig.38 shows the disk array controller 1 in Fig.37 in the rack-mounted form. The two shared memory units 114 shown in Fig.37 are separately packaged in shared memory packages 14 and the two shared memory packages 14 are mounted on different memory platters 3. The two memory platters 3 are interconnected by cable 2 (4-9), one interface platter 2 and the two memory platters 3 are connected by cable 1 (4-2). The cable 2 is a cable for the access path 2 (139) shown in Fig.37.

This configuration produces the same effects as those of embodiment 2. In this embodiment, the shared memory units 114 are interconnected via the access path 2 (139) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 from the channel interface units 111, disk interface units 112 or selector units 113. In this case, it is unnecessary to interconnect the shared memory units 114 via the access path 2 (139). However, if they are interconnected via the access path 2 (139), the data in the two shared memory units 114 can be directly cross-checked

for confirmation or a similar purpose, resulting in improved reliability.

Again, in this case, as shown in Fig.40, the selector units 113 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside).

A dual shared memory system can be realized by arranging two shared memory units 114 as shown in Fig.47. Concretely, two shared memory units 114 are separately packaged in shared memory package and the two packages are mounted on two areas of a memory platter 3 divided by a power supply boundary 300 as in embodiment 3.

This configuration produces the same effects as those of embodiment 3.

Again, in this case, as shown in Fig.49, the selector units 113 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside of the platters).

Fig.23 shows a variation of this embodiment in which cache memory units 115 for storing data to be recorded in magnetic disk drives 120, and shared memory units 114 storing control data for the cache memory units 115 and disk array controller 1 are physically divided, selectors (CM selector units 123) connected to the cache memory units 115 and selectors (SM selector units 113) connected to the

shared memory units 114 are physically independent of each other and access paths a0 (131) and access paths a1 (132) to the shared memory units 114, and access paths b0 (133) and access paths b1 (134) to the cache memory units 115 are independent of each other.

Fig.24 illustrates the configuration of the disk array controller 1 in Fig. 23 in the rack-mounted form. Here, the SM selector units 113 and CM selector units 123 are separately packaged in SM selector packages 13 and CM selector packages 23, respectively. The cache memory units 115 and shared memory units 114 are separately packaged in cache memory unit packages 15 and shared memory packages 14, respectively, which are mounted on a memory platter 3. As shown in Fig.24, in place of the cable 1 (4-2) which connects each interface platter 2 and the memory platter 3 in Fig.6, cable a1 (4-7) for access path a1 (132) to the shared memory units 114 and cable b1 (4-8) for access path b1 (134) to the cache memory units 115 are used.

Since in this configuration, the access paths from the channel interface packages 11 and disk interface packages 12 to the cache memory packages 15 or shared memory packages 14 are physically independent, it is possible to distinguish between faults related to access to the cache memory units 115 (faults in the cache memory units 115, or the CM selector units 123, access paths b0 (133), access paths b1 or others

for access to them) and faults related to access to the shared memory units 114 (faults in the shared memory units 114 or the SM selector units 113, access paths a0 (131), access paths a1 (132) or others for access to them) so that defective parts can be independently repaired without affecting other parts.

Again, in this case, as shown in Fig.26, the SM selector units 113 and CM selector units 123 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside of the platters).

Fig.59 shows a variation of this embodiment in which two shared memory units 114 are interconnected via access path a2 (140) and two cache memory units 115 are interconnected via access path b2 (141) to make a dual system.

Fig.60 illustrates the configuration of the disk array controller 1 in Fig.59 in the rack-mounted form. As shown in Fig.59, like embodiment 5, two shared memory units 114 and two cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, and one shared memory package 14 and one cache memory package 15 are mounted on one memory platter 3, with the two memory platters 3 being interconnected by cable a2 (4-10) and cable b2 (4-11). One interface platter 2 is connected to the two memory platters 3 by cable a1 (4-7) and cable b1 (4-8). The cable a2 (4-10) and cable b2 (4-11) are

cables for the access path a2 (140) and access path b2 (141) shown in Fig.59, respectively.

This configuration produces the same effects as those of embodiment 5.

As shown in Figs. 59 and 60, the shared memory units 114 are interconnected via access path a2 (140) and the cache memory units 115 interconnected via access path b2 (141) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 or both the two cache memory units 115 from the channel interface units 111, disk interface units 112, SM selector units 113 or CM selector units 123. In this case, it is unnecessary to interconnect the shared memory units 114 via access path a2 (140) or the cache memory units 15 via access path b2. However, if they are interconnected via access path a2 (140) or access path b2 (141), the data in the two shared memory units 114 or the two cache memory units 115 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Again, in this case, as shown in Fig.62, the SM selector units 113 and the CM selector units 123 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside of the platters).

Fig.69 is a variation of this embodiment in which two shared memory units 114 and two cache memory units 115 are mounted in the same way as in embodiment 6. In other words, they are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, which are mounted on one memory platter 3 which is divided into two areas by a power supply boundary 300.

This configuration produces the same effects as those of embodiment 6.

Again, in this case, as shown in Fig.71, the SM selector units 113 and CM selector units 123 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside of the platters).
[Embodiment 12]

Figs.9 and 10 show another embodiment of this invention.

Fig.10 shows the configuration of a disk array controller according to this invention. The disk array controller 1 has channel interface units 111, disk interface units 112, selector units 113, shared memory units 114, access paths 0 (135) and access paths 1 (136). It is basically the same in structure as in embodiment 11.

The difference is as follows. In this embodiment, each of the channel interface units 111 and disk interface units 112 has two access paths 0 (135), and one of the paths is

connected to the selector unit 113 in the selector group 150 it belongs to, and the other path connected to the selector unit 113 in the other selector group 150. Therefore, there are two routes for access to the shared memory units 114 from each of the channel interface units 111 or disk interface units 112. Usually the two access routes are used to share the load in a balanced way so that if one access route becomes ineffective due to a fault or other reason, the other access route can be used to operate the system uninterruptedly. A pair of selector groups which each have access paths to the selector in the other group in this way is hereinafter called a redundant system 155.

One selector unit 113 has a total of eight access paths 0 (135) on the basis of one path per unit: paths from the two channel interface units 111 and two disk interface units 112 within the group it belongs, as well as paths from the two channel interface units 111 and two disk interface units 112 within the other group. Also each selector unit 113 has a total of four access paths 1 (136) to the two shared memory units, where each shared memory unit has two access paths. Due to the above-mentioned availability of access paths, each selector unit 113 selects four of the eight requests transmitted via the eight access paths 0 (135) from the channel interface units 111 and disk interface units 112, where the number of selected requests corresponds to the

number of access paths 1 (136) to the shared memory units 114. In this embodiment, the disk array controller 1 has one redundant system 155 and two shared memory units.

Here, the important thing is that the number of access paths 1 (136) from one selector unit 113 to the shared memory units 114 is smaller than the number of access paths 0 (135) from the channel interface units 111 and disk interface units 112 to one selector unit 113, and that the number of selector units 113 is smaller than the total number of channel interface units 111 and disk interface units 112. This reduces the number of access paths to each shared memory unit 114, which means a decrease in the number of cables used, leading to cost reduction. In addition, the problem of LSI pin necks or package connector necks in shared memory units can be resolved.

The number of channel interface units and the number of disk interface units within a selector group 150 depends on the management unit for maintenance (the number of interface units subjected to each maintenance service), and other factors. One possibility is that, on the assumption that the minimum disk array controller configuration constitutes one redundant system 155, a plurality of such redundant systems are provided.

Fig.9 illustrates the configuration of the disk array controller 1 in the rack-mounted form. The channel interface

units 111, disk interface units 112, selector units 113 and shared memory units 114 as shown in Fig.10 are separately packaged in channel interface packages 11, disk interface packages 12, selector packages 13 and shared memory packages 14, respectively. One selector group 150, which consists of one selector package 13 and channel interface packages 11 and disk interface packages 12 connected with it, is mounted on one interface platter 2 and the two shared memory packages 14 are mounted on a memory platter 3 different from the interface platters 2. Each interface platter 2 and the memory platter 3 are connected by cable 1 (4-2). This cable is a cable for the access path 1 (136) which connects a selector unit 113 and a shared memory unit 114 as shown in Fig.10. The two interface platters which constitute a redundant system are interconnected by cable 0 (4-1). This cable is a cable for the access paths 0 (135) which connect the channel interface units 111 and disk interface units 112 within one selector group 150 and the selector unit 113 within the other selector group.

Here, when two cables 0 (4-1) are used instead of one and one of them is used for access path 0 (135) to connect the interface units within one selector group 150 with the selector unit 113 within the other group 150, and the other cable is used for access path 0 (135) to connect the selector unit 113 within the former selector group 150 with the

interface units within the latter selector group 150, even if one of the access paths 0 (135) fails, the cable 0 (4-1) concerned can be replaced without affecting the other access path 0 (135).

Although the selector units 113 are packaged in selector packages in this example, they may also be directly mounted on the reverse of the package bearing surface of the interface platters 2, as shown in Fig.8, without packaging them in packages (the figure shows the back side of the platters).

When, as mentioned above, the access paths of each interface package are connected not only with the selector package 13 on the same interface platter 2 on which it is mounted, but also with the selector package 13 on the other interface platter 2 in the same redundant system, even if the selector package 13 on one of the interface platters 2 fails, the interface packages mounted on the same interface platter 2 bearing the defective selector package 13 can access the shared memory units 114 through the selector unit 113 on the other interface platter 2 and thus the defective selector package 113 can be replaced without stopping the interface units in the selector group 150 to which the defective selector unit 113 belongs. This reduces the number of system components which should be stopped in case of faults.

Variations of this embodiment are introduced below.

In these variations, the selector units 113 may be mounted on the reverse of the package bearing surface of the interface platters 2 (the figures concerned show the backside of the platters).

Fig.42 illustrates a variation of this embodiment in which the two shared memory units 114 are interconnected via access path 2 (139) to make a dual system as in embodiment 2.

Fig.43 illustrates the configuration of the disk array controller 1 in Fig.42 in the rack-mounted form. Two shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on different memory platters 3. The memory platters 3 are interconnected by cable 2 (4-9) and one interface platter 2 and the two memory platters 3 are connected by cable 1 (4-2). The cable 2 (4-9) is a cable for the access path 2 (139) as shown in Fig.42.

This produces the same effects as those of embodiment 2.

In this variation, the shared memory units 114 are interconnected via access paths 2 (139) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 from the channel interface units 111, disk interface units 112 or selector units 113. In this case, it is unnecessary to interconnect the shared memory units 114

via access path 2 (139). However, if they are interconnected via access path 2 (139), the data in the two shared memory units 114 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.51 shows another variation in which two shared memory units 114 make up a dual system. Like embodiment 3, two shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on two areas of one memory platter 3 divided by a power supply boundary 300.

This produces the same effects as those of embodiment 3.

Fig.28 illustrates a variation of this embodiment in which cache memory units 115 for storing data to be recorded in magnetic disk drives 120, and shared memory units 114 for storing control data for the cache memory units 115 and the disk array controller 1 are physically independent of each other, selectors (CM selector units 123) connected to the cache memory units 115 and selectors (SM selector units 113) connected to the shared memory units 114 are physically independent of each other, and access paths a0 (131) and access paths a1 (132) to the shared memory units 114, and access paths b0 (133) and access paths b1 (134) to the cache memory units 115 are independent of each other.

Fig.29 illustrates the configuration of the disk array controller 1 in Fig. 28 in the rack-mounted form. Here, the SM selector units 113 and CM selector units 123 are

separately packaged in SM selector packages 13 and CM selector packages 23, respectively. The cache memory units 115 and shared memory units 114 are separately packaged in cache memory unit packages 15 and shared memory packages 14, respectively, which are mounted on a memory platter 3. In place of the cable 1 (4-2) which connects each interface platter 2 and the memory platter 3 in Fig.9, cable a1 (4-7) for access path a1 (132) to the shared memory units 114 and cable b1 (4-8) for access path b1 (134) to the cache memory units 115 are used as shown in Fig.29. Also, in place of the cable 0 (4-1) which interconnects the interface platters 2, cable a0 (4-5) for access path a0 (131) to the shared memory units 114 and cable b0 (4-6) for access path b0 (133) to the cache memory units 115 are used.

Since in this configuration, the access paths from the channel interface packages 11 and disk interface packages 12 to the cache memory packages 15 or shared memory packages 14 are physically independent, it is possible to distinguish between faults related to access to the cache memory units 115 (faults in the cache memory units 115, or the CM selector units 123, access paths b0 (133), access paths b1 (134) or others for access to them) and faults related to access to the shared memory units 114 (faults in the shared memory units 114 or the SM selector units 113, access paths a0 (131), access paths a1 (132) or others for access to them)

so that defective parts can be independently repaired without affecting other parts.

Fig.64 shows a variation of this embodiment in which two shared memory units 114 are interconnected via access path a2 (140) and two cache memory units 115 are interconnected via access path b2 (141) to make a dual system as in embodiment 5. Fig.65 illustrates the configuration of the disk array controller 1 in Fig.64 in the rack-mounted form. As shown in Fig.65, two shared memory units 114 and two cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, and one shared memory package 14 and one cache memory package 15 are mounted on one memory platter 3, with the two memory platters 3 being connected by cable a2 (4-10) and cable b2 (4-11). The interface platters 2 and memory platters 3 are connected by cables a1 (4-7) and cables b1 (4-8). The cable a2 (4-10) and cable b2 (4-11) are cables for access path a2 (140) and access path b2 (141), respectively.

This produces the same effects as those of embodiment 5.

In this variation, the shared memory units 114 are interconnected via access path a2 (140) and the cache memory units 115 are interconnected via access path b2 (141) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the two shared memory units 114 or both the two cache memory units

115 from the channel interface units 111, disk interface units 112 or SM selector units 113 or CM selector units 123. In this case, it is unnecessary to interconnect the shared memory units 114 or the cache memory units 115 via access path a2 (140) or access path b2 (141). However, if they are interconnected via access path a2 (140) or access path b2 (141), the data in the two shared memory units 114 or the two cache memory units 115 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.73 shows a variation of this embodiment in which two shared memory units 114 and two cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, which are mounted on one memory platter 3 which is divided into two areas by a power supply boundary 300 as in embodiment 6.

This produces the same effects as those of embodiment 6.
[Embodiment 13]

Fig.11 shows another embodiment of this invention.

Fig.11 illustrates one implementation of the disk array controller 1 shown in Fig.4 for embodiment 1 in the rack-mounted form. The channel interface units 111, disk interface units 112 and shared memory units 114 as shown in Fig.4 are separately packaged in channel interface packages 11, disk interface packages 12, and shared memory packages

14, respectively. Two channel interface packages 11, two disk interface packages 12 and one shared memory package 14, which constitute a group called a cluster (165, 166), are mounted on one interface platter 2.

Therefore, the configuration of this embodiment differs from that of embodiment 1 in Fig. 1 in that a shared memory package 14 is mounted on an interface platter 2 together with channel interface packages 11 and disk interface packages 12.

This embodiment has two clusters, cluster 0 (165) and cluster 1 (166). However, the numbers of clusters, and the number of channel interface units, disk interface units and shared memory units 113 in one cluster are not limited as above. These numbers depend on the minimum or maximum system configuration of the disk array controller, and the minimum unit of system expansion. In other words, they depend on performance, cost, scalability and other requirements. One possibility is that one cluster is made up of a minimum disk array controller configuration.

In adding an interface platter 2, the new interface platter 2 and the existing interface platters 2 are connected by two cables 4. These cables 4 are cables for the access paths 0 (135) (shown in Fig.4) which connect the channel interface units 111 or disk interface units 112

within one cluster, with the shared memory unit 114 within the other cluster.

Although each of the two clusters contains a shared memory package 14 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 used in the disk array controller 1 while the other cluster has no shared memory package 14. This can reduce the number of cluster interconnection cables 4 shown in Fig.11 to one, which leads to cost reduction.

The disk array controller in this embodiment uses a smaller number of cables than that in embodiment 1, leading to cost reduction and higher implementation efficiency.

Figs. 33, 46, 19, 55 and 68 illustrate variations of this embodiment. These show other configurations of the disk array controller detailed in the description of embodiments 2 to 6. They are different from the configuration of the disk array controller in embodiments 2 to 6 simply in that a shared memory package 14 is mounted on an interface platter 2 together with channel interface packages 11 and disk interface packages 12. They will be briefly outlined below. Needless to say, they produce the same effects as those of embodiments 2 to 6.

Fig.33 shows one implementation of the disk array controller 1 shown in Fig. 31 for embodiment 2. The configuration in Fig.33 differs from that in Fig.32 for

embodiment 2 in that one cluster contains one shared memory package 14.

Fig.46 shows a variation of the configuration shown in Fig.45 for embodiment 3. Two pairs of shared memory packages 14 are mounted on different interface platters 2. Each of the interface platters is divided by a power supply boundary 300 into two areas, to which power is separately supplied from two power supplies. Each shared memory package 14 in one pair is mounted in one of the areas to which power is supplied from different power supplies.

Fig. 19 illustrates one implementation of the disk array controller 1 shown in Fig.17 for embodiment 4. Fig.19 is different from Fig.18 for embodiment 4 only in that a cluster contains one shared memory package 14 and one cache memory package 15.

Fig.55 illustrates one implementation of the disk array controller 1 shown in Fig.53 for embodiment 5. Fig.55 is different from Fig.54 for embodiment 5 only in that a cluster contains one shared memory package 14 and one cache memory package 15.

Fig.68 shows a variation of the implementation shown in Fig.67 for embodiment 6. Each of the interface platters is divided by a power supply boundary 300 into two areas, to which power is separately supplied from two power supplies. One shared memory package 14 and one cache memory package

15 are mounted in one of these areas energized by different power supplies.

[Embodiment 14]

Fig.12 shows another embodiment of this invention.

Fig. 12 shows the configuration of another disk array controller according to this invention. The disk array controller 1 has the following: channel interface units 111; disk interface units 112; shared memory units 114; two shared buses 0 (31) which connect them; shared bus interconnect controllers 140 for connection of the shared buses 0 (31) from different clusters; and access paths 0 (135). The relationship among the channel interface units 111, disk interface units 112 and shared memory units 114 is the same as in embodiment 7.

In this embodiment, two channel interface units 111, two disk interface units 112, one shared memory unit 114, two shared buses 0 (31) and two shared bus interconnect controllers 140 constitute one group, which is here called a cluster. In this embodiment, the disk array controllers has two clusters (165, 166).

The shared bus interconnect controllers 140 work as follows to connect shared buses from different clusters.

For access from a channel interface unit 111 or disk interface unit 112 within one cluster to the shared memory 114 in the other cluster, the SM access circuit (not shown

here) inside the channel interface unit 111 or disk interface unit 112 obtains the right to use the shared buses 0 (31) and then accesses a shared bus interconnect controller 140 connected with the shared buses 0 (31) to issue a request for access to the shared memory unit 114 within the other cluster. That shared bus interconnect controller 140 sends the access request to a shared bus interconnect controller 140 connected with the shared buses 0 (31) within the other cluster. After obtainment of the right to use the shared buses 0 (31), the shared bus interconnect controller connected with the shared buses 0 (31) within the other cluster sends the access request to the shared memory unit.

For connection of the clusters, the shared memory units 114 may be interconnected via access paths 0 (135) as shown in Fig.13. The disk array controller 1 operates as each of the channel interface units 111 and disk interface units 112 accesses the shared memory units; so, by interconnecting the shared memory units 114 as mentioned above, the channel interface units 111 and disk interface units 112 can each access the shared memory units 114.

Needless to say, the number of clusters is not limited as above.

One shared bus 0 (31) may be used instead of two. However, the use of two shared buses makes the access paths to the

shared memory units 114 redundant, resulting in improved trouble resistance.

Fig.11 shows the configuration of the disk array controller 1 in Fig.12 or 13 in the rack-mounted form. The channel interface units 111, disk interface units 112 and shared memory units 114 as shown in Fig.12 or 13 are separately packaged in channel interface packages 11, disk interface packages 12 and shared memory packages 14, respectively. Channel interface packages 11, disk interface packages 12 and a shared memory package 14, all of which constitute one cluster, are mounted on one interface platter 2. Shared buses 0 (31) are wired on the interface platter 2 and shared bus interconnect controllers 140 are directly mounted thereon (these are not shown in the figure). In the configuration in Fig.13, the shared buses are wired on the interface platter 2 but the shared bus interconnect controllers 140 are not mounted thereon.

In adding an interface platter 2, the new interface platter 2 and the existing interface platters 2 are connected by two cables 4. In case of the disk array controller 1 in Fig.12, these cables correspond to cables for the access paths 0 (135) which connect shared bus interconnect controllers 140 within one cluster, with those within the other cluster, while, in case of the disk array controller 1 in Fig.13, they are cables for the access paths

0 (135) which connect the shared memory unit 114 within one cluster with that in the other cluster.

This configuration not only produces the same effects as those of embodiment 7 but also a further effect: Since each cluster contains a shared memory unit 114, this disk array controller is less scalable than that in embodiment 7 but the number of cables used can be decreased, leading to cost reduction and higher implementation efficiency.

Variations of this embodiment are introduced below.

Fig.35 shows a variation of this embodiment in which, in the disk array controller 1 in Fig.12, two shared memory units 114 are interconnected via access path 2 (139) to make a dual system as in embodiment 2. Fig.33 illustrates the configuration of the disk array controller 1 in Fig.35 in the rack-mounted form. Two shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on different interface platters 2. The interface platters 2 are interconnected by cable 2 (4-9). The cable 2 (4-9) is a cable for access path 2 (139). In case of the disk array controller 1 in Fig.13, the same dual system effect can be obtained by connecting the shared memory unit 114 within one cluster with that within the other cluster via access path 2 (139) as shown in Fig.36.

It is also possible that one access path serves as both access path 0 (135) for access from a channel interface unit

2025 RELEASE UNDER E.O. 14176

111 or disk interface unit 112 within one cluster to the shared memory unit 114 within the other cluster, and the access path 2 (139) to make a dual system. It must be noted that the throughput of such an access path should be higher than the sum of the throughput of the access paths 0 (135) and that of the access path 2 (139); otherwise, the overall throughput of the disk array controller 1 would deteriorate.

This produces the same effects as those of embodiment 2.

Another possible approach to making a dual system is that one cluster contains two interconnected shared memory units 114 instead of interconnecting two shared memory units 114 of different clusters.

Fig.46 shows a variation in which a shared memory unit 114 is added to one cluster and the two shared memory units 114 in the cluster are separately packaged in shared memory packages 14, which are mounted on the two areas of the interface platter 2 divided by a power supply boundary 300 as in embodiment 3.

This produces the same effects as those of embodiment 3.

Fig.21 shows a variation of the disk array controller 1 in Fig.12 in which the cache memory units 115 for storing data to be recorded in magnetic disk drives 120 and the shared memory units 114 for storing control data for the cache memory units 115 and disk array controller 1 are physically independent as in embodiment 4. Here, the shared

buses 0 (31) shown in Fig.12 are divided into shared buses b0 (35) for transmitting data from the magnetic disk drives 120 and shared buses a0 (33) for transmitting control data for the cache memory units 115 and disk array controller 1, and the channel interface units 111 and disk interface units 112 are connected to both the shared buses a0 (33) and shared buses b0 (35). Further, the cache memory units 115 and shared memory units 114 are connected to the shared buses b0 (35) for transmitting data from the magnetic disk drives 120 and shared buses a0 (33) for transmitting control data for the disk array controller 1, respectively. Connections are made between the shared buses a0 (33) of the different clusters and between the shared buses b0 (35) of the different clusters through shared bus interconnect controllers 140, via access paths a (137) and access paths b (138), respectively. As a variation of the disk array controller 1 in Fig.13, as shown in Fig.22, connections are made between the shared memory units 114 of the different clusters and between the cache memory units 115 of the different clusters via access paths a (137) and access paths b (138), respectively.

Fig. 19 shows the configuration of the disk array controller 1 in Fig.21 or Fig.22 in the rack-mounted form. The cache memory units 115 and shared memory units 114 are separately packaged in cache memory packages 15 and shared

memory packages 14, respectively, which are mounted on an interface platter 2. The cables 4 shown in Fig.11 which interconnect interface platters 2 are divided into cables a (4-3) for access paths a (137) for connection between shared buses a0 (33) and cables b (4-4) for access paths b (138) for connection between shared buses b0 (35) as shown in Fig.19.

This produces the same effects as those of embodiment 4.

Fig.57 shows a variation of the disk array controller 1 in Fig.12 in which the two shared memory units 114 are interconnected via access path a2 (140) and the two cache memory units 115 are interconnected via access path b2 (141) as in embodiment 5. As a variation of the disk array controller 1 in Fig.13, access path a2 (140) and access path b2 (141) for a dual system should be provided as shown in Fig.58. It is also possible that one access path serves as both access path a0 (131) for access from a channel interface unit 111 or disk interface unit 112 within one cluster to the shared memory unit 114 within the other cluster, and the access path a2 (140) to make a dual system. It is also possible that one access path serves as both access path b0 (133) for access from a channel interface unit 111 or disk interface unit 112 within one cluster to the cache memory unit 115 within the other cluster, and the access path b2 (141) to make a dual system. In that case, it must be noted

that the throughput of such an access path for the shared memory units should be higher than the sum of the throughput of the access path a0 (131) and that of the access path a2 (140), and the throughput of such an access path for the cache memory units should be higher than the sum of the throughput of the access path b0 (133) and that of the access path b2 (141); otherwise, the overall throughput of the disk array controller 1 would deteriorate.

Fig. 55 shows the configuration of the disk array controller 1 in Fig.57 or Fig.58 in the rack-mounted form. The shared memory units 114 and cache memory units 115 are separately packaged in shared memory packages 14 and cache memory packages 15, respectively, which are mounted on different interface platters 2, with the interface platters 2 being interconnected by cable a2 (4-10) and cable b2 (4-11). The cable a2 (4-10) is a cable for the access path a2 (140) and the cable b2 (4-11) is a cable for the access path b2 (141).

This produces the same effects as those of embodiment 5.

Another possible approach to making a dual system is that one cluster contains two interconnected shared memory units 114 and two interconnected cache memory units 115 instead of interconnecting two shared memory units 114 and two cache memory units 115 of different clusters as in Figs.57 and 58.

Fig.68 shows a variation which uses two pairs of interconnected shared memory packages 14 and two pairs of interconnected cache memory packages 15, where one shared memory package and one cache memory package are mounted on each of the two areas of the interface platter 2 divided by a power supply boundary 300 as in embodiment 6.

This produces the same effects as those of embodiment 6.

[Embodiment 15]

Fig.14 shows another embodiment of this invention.

Fig.14 shows one configuration of the disk array controller 1 shown in Fig. 7 for embodiment 11 in the rack-mounted form. A selector group 150, which consists of one selector package 13, and channel interface packages 11 and disk interface packages 12 which are connected with it, and one shared memory package 14 are mounted on one interface platter 2. All these on the platter constitute one cluster as defined earlier.

In adding an interface platter 2, the new interface platter 2 and the existing interface platters 2 are connected by two cables 1 (4-2). These cables 1 (4-2) are cables for the access paths 1 (136) which connect the selector unit 113 within one cluster, with the shared memory unit 114 within the other cluster. In short, the configuration of this embodiment is different from the

configuration of embodiment 11 shown in Fig.6 in that each shared memory package is mounted on an interface platter 2.

Although the selector units 113 are mounted in selector packages 13 in this example, they may be directly mounted on the reverse of the package bearing surface of the interface platters 2 without packaging them in packages as shown in Fig.15 (the figure shows the backside of the platters). This reduces the required width of each interface platter 2 by the amount equivalent to the width of the selector package 13, permitting the rack for the disk array controller 1 to be more compact.

Although each of the two clusters contains a shared memory package 14 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 used in the disk array controller 1 while the other cluster has no shared memory package 14. This can decrease the number of cluster interconnection cables 1 (4-2) shown in Fig.14 to one, which leads to cost reduction.

This configuration not only produces the same effects as those of embodiment 11 but also a further effect: Since each cluster contains a shared memory unit 114, this disk array controller is less scalable than that of embodiment 11 but the number of cables used can be decreased, leading to cost reduction and higher implementation efficiency.

Variations of this embodiment are introduced below. These variations are different from the variations of embodiment 11 only in that shared memory packages 14 are mounted on interface platters 2; they are briefly outlined next.

In these variations, it is also acceptable that the selector packages 113 are directly mounted on the reverse of the package bearing surface of the interface platters 2, without packaging them in packages (the figure shows the backside of the platters).

Fig.39 illustrates a configuration in the rack-mounted form of the disk array controller 1 of embodiment 11 in Fig.37. In this variation, two shared memory units 114 are interconnected in the same way as in embodiment 2.

This produces the same effects as those of embodiment 2.

In this variation, the shared memory units 114 are interconnected via access path 2 (139) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the shared memory units 114 from the channel interface units 111, disk interface units 112 or selector units 113. In this case, it is unnecessary to interconnect the shared memory units 114 via access path 2 (139). However, if they are interconnected via access path 2 (139), the data in the two shared memory

units 114 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.48 shows a variation in which a shared memory unit 114 is added to one cluster and the two shared memory units 114 in the cluster are separately packaged in shared memory packages 14, which are mounted on the two areas of the interface platter 2 divided by a power supply boundary 300 as in embodiment 3.

This produces the same effects as those of embodiment 3.

Although each of the two clusters contains shared memory packages 14 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 used in the disk array controller 1 while the other cluster has no shared memory packages 14. This can decrease the number of cluster interconnection cables 1 (4-2) in Fig.48 to one, which leads to cost reduction and higher implementation efficiency.

Fig.23 shows a variation in which, as in embodiment 4, each shared memory unit 114 of the disk array controller 1 in Fig.7 is physically divided into a cache memory unit 115 for storing data to be recorded in magnetic disk drives 120, and a shared memory unit 114 for storing control data for the cache memory unit 115 and disk array controller 1. Selectors (CM selector units 123) connected to the cache memory units 115, and selectors (SM selector units 113)

connected to the shared memory units 114 are physically independent, and access paths a0 (131) and access paths a1 (132) to the shared memory units 114, and access paths b0 (133) and access paths b1 (134) to the cache memory units 115, are independent of each other.

This produces the same effects as those of embodiment 4.

Although each of the two clusters contains a shared memory package 14 and a cache memory package 15 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 and cache memory packages 15 used in the disk array controller 1 while the other cluster has no shared memory package 14 nor cache memory package 15. This can decrease the number of cluster interconnection cables a1 (4-7) and the number of cables b1 (4-8) shown in Fig.25 to one, which leads to cost reduction.

Fig.59 shows a variation in which two shared memory units 114 are interconnected via access path a2 (140) and two cache memory units 115 are interconnected via access path b2 (141) to make a dual system.

Fig.61 shows the configuration of the disk array controller 1 in Fig.59 in the rack-mounted form. One shared memory package 14 and one cache memory package 15 are mounted on an interface platter 2, with the interface platters 2 being interconnected by cable a2 (4-10) and cable b2 (4-11). The cable a2 (4-10) is a cable for the access path a2 (140)

and the cable b2 (4-11) is a cable for the access path b2 (141).

This produces the same effects as those of embodiment 5.

In this variation, the shared memory units 114 are interconnected via access path a2 (140) and the cache memory units 115 via access path b2 (141) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the shared memory units 114 or both the cache memory units 115 from the channel interface units 111, disk interface units 112 or SM selector units 113 or CM selector units 123. In this case, it is unnecessary to interconnect the shared memory units 114 via access path a2 (140) or the cache memory units 115 via access path b2 (141). However, if they are interconnected via access path a2 (140) or b2 (141), the data in the two shared memory units 114 or two cache memory units 115 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.70 shows a variation in which two shared memory packages 14 and two cache memory packages 15 are contained in one cluster instead of one memory package 14 and one cache memory package 15 in each of the clusters shown in Fig.59, where one set which consists of one shared memory package 14 and one cache memory package 15 is mounted on each of the

two areas of the interface platter 2 divided by a power supply boundary 300.

This produces the same effects as those of embodiment 6.

It is also acceptable that one cluster contains all the shared memory packages 14 and cache memory packages used in the disk array controller 1 while the other cluster has no shared memory package 14 nor cache memory package 15. This can decrease the number of cluster interconnection cables a1 (4-7) and the number of cables b1 (4-8) shown in Fig.70 to one, which leads to cost reduction.

[Embodiment 16]

Fig.16 shows another embodiment of this invention.

Fig.16 illustrates one configuration in the rack-mounted form of the disk array controller 1 of embodiment 12 shown in Fig.10. This configuration is different from that of embodiment 12 in Fig.9 in that the shared memory units in Fig.10 are contained in clusters.

In this configuration, as compared to the configuration in Fig.9, the number of access paths 1 (136) which connect the selector units (113) and shared memory units 114 can be decreased, which decreases the number of cables used in the disk array controller housed in the rack, leading to cost reduction.

Although the selector units 113 are packaged in selector packages 13 in this example, they may be directly

mounted on the reverse of the package bearing surface of the interface platters 2 without packaging them in packages (the figure shows the backside of the platters). This reduces the required width of each interface platter 2 by the amount equivalent to the width of the selector package 13, permitting the rack for the disk array controller 1 to be more compact.

Although each of the two clusters contains a shared memory package 14 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 used in the disk array controller 1 while the other cluster has no shared memory package 14. This can decrease the number of cluster interconnection cables 1 (4-2) shown in Fig.16 to one, which leads to cost reduction.

Variations of this embodiment are introduced below. These variations are different from the variations of embodiment 12 only in that shared memory units 114 are contained in clusters; they are briefly outlined next.

Again, by mounting the selector units 113 directly on the reverse of the package bearing surface of the interface platters 2 (the figure shows the backside of the platters), the required width of each interface platter 2 can be reduced, permitting the rack for the disk array controller 1 to be more compact.

Fig.44 shows a variation of the disk array controller 1 in Fig.42, in which two shared memory units 114 are separately packaged in shared memory packages 14, which are mounted on different interface platters 2.

Also, the same dual system effect can be obtained by writing the same data in both the shared memory units 114 from the channel interface units 111, disk interface units 112 or selector units 113. In this case, it is unnecessary to interconnect the shared memory units 114 via access path 2 (139). However, if they are interconnected via access path 2 (139), the data in the two shared memory units 114 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.52 shows a variation of the configuration in Fig. 42 in which one cluster contains two shared memory packages 14 instead of one, where one shared memory package 14 in a dual system is mounted on each of the two areas of each interface platter 2 divided by a power supply boundary 300 as in embodiment 3.

Although each of the two clusters contains shared memory packages 14 in this example, it is also acceptable that one of the two clusters contains all the shared memory packages 14 used in the disk array controller 1 while the other cluster has no shared memory packages 14.

Fig.30 illustrates a variation in which, as in embodiment 4, each shared memory unit 114 is physically divided into a cache memory unit 115 for storing data to be recorded in magnetic disk drives 120, and a shared memory unit 114 for storing control data for the cache memory unit 115 and the disk array controller 1.

Since in this configuration, the access paths from the channel interface packages 11 and disk interface packages 12 to the cache memory packages 15 or shared memory packages 14 are physically independent, it is possible to distinguish between two types of faults, faults related to access to the cache memory units 115 (faults in the cache memory units 115, or the CM selector units 123, access paths b0 (133), access paths b1 (134) or others for access to them) and faults related to access to the shared memory units 114 (faults in the shared memory units 114 or the SM selector units 113, access paths a0 (131), access paths a1 or others for access to them) so that defective parts can be independently repaired without affecting other parts.

Although each of the two clusters contains a shared memory package 14 and a cache memory package 15 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 and cache memory packages 15 used in the disk array controller 1 while the other cluster has no shared memory package 14 nor cache memory package 15.

Fig.66 shows a variation in which two shared memory units 114 are interconnected via access path a2 (140) and two cache memory units 115 via access path b2 (141) as in embodiment 5.

This produces the same effects as those of embodiment 5.

In this embodiment, the shared memory units 114 are interconnected via access path a2 (140) and the cache memory units 115 via access path b2 (141) to make a dual system; however, instead, the same dual system effect can be obtained by writing the same data in both the shared memory units 114 or both the cache memory units 115 from the channel interface units 111, disk interface units 112, or SM selector units 113 or CM selector units 123. In this case, it is unnecessary to interconnect the shared memory units 114 or cache memory units via access path a2 (140) or access path b2 (141). However, if they are interconnected with access path a2 (140) or access path b2 (141), the data in the two shared memory units 114 or the two cache memory units 115 can be directly cross-checked for confirmation or a similar purpose, resulting in improved reliability.

Fig.74 shows a variation in which one cluster contains two shared memory packages 14 and two cache memory packages 15, where a set which consists of one shared memory package 14 and one cache memory package 15 is mounted on each of the

two areas of the interface platter 2 divided by a power supply boundary 300, as in embodiment 6.

This produces the same effects as those of embodiment 6.

Although each of the two clusters contains shared memory packages 14 and cache memory packages 15 in this example, it is also acceptable that one cluster contains all the shared memory packages 14 and cache memory packages 15 used in the disk array controller 1 while the other cluster has no shared memory package 14 nor cache memory package 15. [Embodiment 17]

Figs.75 and 77 show another embodiment in which the disk array controller 1 of embodiment 12 in Fig.64 is mounted in the rack.

Fig.75 illustrates how packages are mounted on platters and how the platters are positioned and interconnected. Each interface platter 2 bears two channel interface packages 11 and two disk interface packages 12, which constitute one selector group 150. The selector units (SM selector units) 113 connected to the shared memory packages, and the selector units (CM selector units) 123 connected to the cache memory packages are mounted on the backside of the interface platters 2. This arrangement can decrease the required width of the interface platters 2. Two interface platters make up a redundant system 155.

The disk array controller 1 has eight interface platters 2 which make up four redundant systems 155. One memory platter 3 bears one shared memory package 14 and two cache memory packages 15. To make a dual memory system, two memory platters 3 are provided.

Between two interface platters which constitute a redundant system, the channel interface packages 11 and disk interface packages 12 are connected with the SM selector units 113 and CM selector units 123 by cable a0 (4-5) and cable b0 (4-6), respectively.

Here, when two cables a0 (4-5) and two cables b0 (4-6) are used and one of the two cables is used for the access path to connect the interface units within one selector group 150 with the selector units within the other selector group 150, and the other cable is used for the access path to connect the selector units within the former selector group 150 with the interface units within the latter selector group 150, even if one of the access paths fails, the cable a0 (4-5) or cable b0 (4-6) can be replaced without affecting the other access path.

Each interface platter 2 is connected with four cables from two memory platters 3, where one cable a1 (4-7) and one cable b1 (4-8) come from each memory platter. This means that each memory platter is connected with a total of 16 cables from eight interface platters 2, where one cable a1 (4-7)

and one cable b1 (4-8) come from each interface platter. The memory platters 3 are interconnected by cable a2 (4-10) and cable b2 (4-11).

Connectors for the cables which interconnect the platters are located on the backside of the platters, where the inter-platter cables are connected. This eliminates the need for detouring the inter-platter cables around the cables (not shown) for connection with the host computer 101 at the sub edge side of the channel interface packages 11 (opposite to the side where the packages are connected with the platters) or the cables (not shown) for connection with the magnetic disk drives 120 at the sub edge side of the disk interface packages 12, shortening the required cable length.

As mentioned earlier, the cables used here are expensive. Data transmission at high frequencies by cables could cause noise, which often makes the implementation difficult. For this reason, to shorten the cable length offers a great advantage.

In this embodiment, the interface platters 2 and memory platters 3 are virtually perpendicular to each other. This makes it possible to locate the connectors for the cables which connect the interface platters 2 and memory platters 3 so that the cables can be shortened as shown in Fig.75.

Fig.75 shows that the interface platters 2 are vertical to the horizontal plane and the memory platters 3 are parallel to the horizontal plane; however, they may be oriented vice versa.

Also as shown in Fig.75, the interface platters 2 may be located so that the memory platters 3 are sandwiched by them. This can also shorten the cables which connect the interface and memory platters.

Fig.77 shows the platters in Fig.75 which is housed in the rack 180. The platters bearing the packages are located on the front side in the rack and power supplies 0 (170) and 1 (171) are located behind them.

The power supplies 0 (170) and 1 (171) are separately connected with the platters, which facilitates power supply control during platter replacement.

As shown in Fig.77, power may be supplied to each platter from a dual power supply system consisting of a power supply 0 (170) and a power supply 1 (171). When such a dual power supply system is used, even if one of the power supplies fails, the other power supply is used; therefore, it is unnecessary to shut down the packages on the platter which has been energized by the defective power supply, decreasing the number of system components to be stopped in case of failure.

[Embodiment 18]

Figs.76 and 78 show an embodiment in which the disk array controller 1 of embodiment 12 in Fig.28 is mounted in the rack.

Fig.76 illustrates how packages are mounted on platters and how the platters are positioned and interconnected. Each interface platter 2 bears two channel interface packages 11 and two disk interface packages 12, which constitute one selector group 150, as well as one shared memory package 14 and one cache memory package 15. The selector units (SM selector units) 113 connected to the shared memory packages, and the selector units (CM selector units) 123 connected to the cache memory packages are mounted on the backside of the interface platters 2. This can reduce the required width of the interface platters 2. Two interface platters make up a redundant system 155. The disk array controller 1 has two interface platters 2 which make up one redundant system 155.

Between two interface platters which constitute a redundant system 155, the channel interface packages 11 and disk interface packages 12 are connected with the SM selector units 113 and CM selector units 123 by cable a0 (4-5) and cable b0 (4-6), respectively.

Here, when two cables a0 (4-5) and two cables b0 (4-6) are used and one of the two cables is used for the access path to connect the interface units within one selector

group 150 with the selector units within the other group 150 and the other cable is used for the access path to connect the selector units within the former selector group 150 with the interface units within the latter selector group 150, even if one of the access paths fails, the cable a0 (4-5) or cable b0 (4-6) can be replaced without affecting the other access path.

Between the platters, the SM selector units 113 and CM selector units 123 are connected with the shared memory units 114 and cache memory units 115 by two cables a1 (4-7) and two cables b1 (4-8), respectively. The two shared memory units 113 as a dual system and the two cache memory units 115 as a dual system are interconnected by cable a2 (4-10) and cable b2 (4-11), respectively. Therefore, the two interface platters are interconnected by a total of eight cables. However, the number of cables which can be used here is not limited as above.

Connectors for the cables which interconnect the platters are located on the backside of the platters, where the inter-platter cables are connected. This eliminates the need for detouring the inter-platter cables around the cables (not shown) for connection with the host computer 101 at the sub edge side of the channel interface packages 11 (opposite to the side where the packages are connected with the platters) or the cables (not shown) for connection with

the magnetic disk drives 120 at the sub edge side of the disk interface packages 12, shortening the required cable length.

The interface platters 2 may be vertically arranged as shown in Fig.76. This arrangement can shorten the cable length required to interconnect the platters.

Fig.78 shows the platters in Fig.76 which is housed in the rack 180. The platters bearing the packages are located on the front side in the rack and power supplies 0 (170) and 1 (171) are located behind them.

The power supplies 0 (170) and 1 (171) are separately connected with the platters, which facilitates power supply control during platter replacement.

As shown in Fig.78, power may be supplied to each platter from a dual power supply system consisting of one power supply 0 (170) and one power supply 1 (171). When such a dual power supply system is used, even if one of the power supplies fails, the other power supply can be used; therefore, it is unnecessary to shut down the packages on the platter which has been energized by the defective power supply, decreasing the number of system components to be stopped in case of failure.

[Embodiment 19]

Figs.79 and 80 show another embodiment in which the disk array controller 1 of embodiment 12 in Fig.28 is mounted in what is called a 19-inch rack (185).

Fig.79 illustrates the disk array controller 1 housed in a 19-inch rack 185. Each MP box 250 houses channel interface packages 11, disk interface packages 12, a shared memory (SM) selector package 13 and a cache memory (CM) selector package 23. Shared memory packages 14 and cache memory packages 15 are housed in an MEM box 251. All power supplies are housed in a PS box 252. Thus, the disk array controller 1 consists of four MP boxes 250, one MEM box 251 and one PS box 252.

Fig.81 shows, as an example, how channel interface packages 11, disk interface packages 12, SM selector packages 13 and CM selector packages 23 are housed in an MP box 250. One interface platter 2 bears a selector group 150 which consists of two channel interface packages 11, two disk interface packages 12, one SM selector package 13 and one CM selector packages 23.

Each interface platter is connected with two cables a1 (4-7) for connecting an SM selector package 13 with shared memory packages 14 and two cables b1 (4-8) for connecting a CM selector package 23 with cache memory packages 15.

One MP box 250 houses two interface platters 2 which constitute a redundant system 155. These two interface

platters 2 are interconnected by cable a0 (4-5) and cable b0 (4-6) as shown in Fig. 80 to make up a redundant system.

Here, when two cables a0 (4-5) and two cables b0 (4-6) are used and one of the two cables is used for the access path to connect the interface units within one selector group 150 with a selector unit within the other selector group 150 and the other cable is used for the access path to connect a selector unit within the former selector group 150 with the interface units within the latter selector group 150, even if one of the access paths fails, the cable a0 (4-5) or cable b0 (4-6) can be replaced without affecting the other access path.

Four cables 302 for connection with the host computer 101 are connected at the sub edge side (opposite to the side where the packages are connected with the platters) of each channel interface package 11, and four cables 301 for connection with the magnetic disk drives 120 are connected at the sub edge side of each disk interface package 12.

Fig.82 shows, as an example, how shared memory packages 14 and cache memory packages 15 are housed in the MEM box 251. One memory platter bears two packages: one shared memory package 14 and one cache memory package 15.

Each memory platter 3 is connected with eight cables: cables a1 (4-7) for connection between the SM selector packages 13 and shared memory packages 14 and cables b1 (4-8)

for connection between the CM selector packages 23 and cache memory packages 15.

To make a dual memory system, two memory platters 3 are housed in the MEM box 251 and the two memory platters 3 are interconnected by cable a2 (4-10) and cable b2 (4-11) as shown in Fig.80.

Fig.83 shows, as an example, how power supplies are housed in the PS box 252. To one MP box, power is supplied from MP box power supply groups 175 each of which is composed of six power supply modules 172. The six power supply modules in each group constitute two 3-module sets to make a dual system. Power is supplied to one MEM box from an MEM box power supply group 176 composed of four power supply modules 172. These four power supply modules 172 constitute two 2-module sets to make a dual system. To back up the shared memory units 114 and cache memory units 115 in case of power failure, two memory backup batteries 177 are provided.

Because the disk array controller1 consists of four MP boxes 250 and one MEM box 251, the PS box 252 houses four MP box power supply groups 175 and one MEM box power supply group 176.

Fig.80 illustrates inter-platter cable connections. Between two interface platters constituting a redundant system, the channel interface packages 11 and disk interface packages 12 are connected with the SM selector units 113 and

CM selector units 113 by cable a0 (4-5) and cable b0 (4-6), respectively.

Each interface platter 2 is connected with a total of four cables from two memory platters 3 where one cable a1 (4-7) and one cable b1 (4-8) come from each memory platter. Therefore, each memory platter 3 is connected with a total of 16 cables from eight interface platters 2, where one cable a1 (4-7) and one cable b1 (4-8) come from each interface platter.

The two memory platters 3 are interconnected by cable a2 (4-10) and cable b2 (4-11) to make a dual system of shared memory units 114 and a dual system of cache memory units 115.

The interface platters 2 are located so that the memory platters 3 are sandwiched by them. This can also shorten the cables which connect the interface and memory platters.

When the interface packages, memory packages and power supplies are housed in their respective boxes and the boxes are housed in the rack as mentioned above, the disk array controller 1 can be serviced box by box and thus its maintenance is easier.

In addition, a commercially available 19-inch rack can be used for the disk array controller, so it is possible to configure a workstation, server or other system housed in a 19-inch rack which includes storages.

So far, the best modes for embodying the invention have been explained using various embodiments. The invention may be embodied in other specific forms. For instance, in embodiments where channel interface units and disk interface units are not connected via shared buses, it is also possible to mount the channel interface packages and disk interface packages on different platters as mentioned for embodiment 1. In embodiments which have both shared memory units and cache memory units, it is also possible to mount the shared memory packages and cache memory packages on different platters. The above explanations have been made for a disk array controller which uses magnetic disk drives, but DVD-RAMs, magnet-optical disks, magnetic tape or other storages may be used in place of magnetic disk drives.

According to this invention, even if one platter fails, only components for which the packages mounted on that platter are responsible have to be stopped and a defective part on the platter can be replaced without stopping the entire system; in other words, faults can be remedied without stopping the system so that the system can be operated without interruption around the clock, all the year round.

In addition, to cope with the increase or decrease in the number of platters bearing interface packages, the performance of internal buses can be made scalable.

Therefore, scalability of performance and capacity is assured to suit a wide range of systems from small to large systems without unfavorably affecting the cost performance. Besides, it becomes possible to supply products at reasonable prices which match the scale of the system.

1. $\frac{1}{2}$ 2. $\frac{1}{3}$ 3. $\frac{1}{4}$ 4. $\frac{1}{5}$ 5. $\frac{1}{6}$ 6. $\frac{1}{7}$ 7. $\frac{1}{8}$ 8. $\frac{1}{9}$ 9. $\frac{1}{10}$ 10. $\frac{1}{11}$ 11. $\frac{1}{12}$ 12. $\frac{1}{13}$ 13. $\frac{1}{14}$ 14. $\frac{1}{15}$ 15. $\frac{1}{16}$ 16. $\frac{1}{17}$ 17. $\frac{1}{18}$ 18. $\frac{1}{19}$ 19. $\frac{1}{20}$ 20. $\frac{1}{21}$ 21. $\frac{1}{22}$ 22. $\frac{1}{23}$ 23. $\frac{1}{24}$ 24. $\frac{1}{25}$ 25. $\frac{1}{26}$ 26. $\frac{1}{27}$ 27. $\frac{1}{28}$ 28. $\frac{1}{29}$ 29. $\frac{1}{30}$ 30. $\frac{1}{31}$ 31. $\frac{1}{32}$ 32. $\frac{1}{33}$ 33. $\frac{1}{34}$ 34. $\frac{1}{35}$ 35. $\frac{1}{36}$ 36. $\frac{1}{37}$ 37. $\frac{1}{38}$ 38. $\frac{1}{39}$ 39. $\frac{1}{40}$ 40. $\frac{1}{41}$ 41. $\frac{1}{42}$ 42. $\frac{1}{43}$ 43. $\frac{1}{44}$ 44. $\frac{1}{45}$ 45. $\frac{1}{46}$ 46. $\frac{1}{47}$ 47. $\frac{1}{48}$ 48. $\frac{1}{49}$ 49. $\frac{1}{50}$ 50. $\frac{1}{51}$ 51. $\frac{1}{52}$ 52. $\frac{1}{53}$ 53. $\frac{1}{54}$ 54. $\frac{1}{55}$ 55. $\frac{1}{56}$ 56. $\frac{1}{57}$ 57. $\frac{1}{58}$ 58. $\frac{1}{59}$ 59. $\frac{1}{60}$ 60. $\frac{1}{61}$ 61. $\frac{1}{62}$ 62. $\frac{1}{63}$ 63. $\frac{1}{64}$ 64. $\frac{1}{65}$ 65. $\frac{1}{66}$ 66. $\frac{1}{67}$ 67. $\frac{1}{68}$ 68. $\frac{1}{69}$ 69. $\frac{1}{70}$ 70. $\frac{1}{71}$ 71. $\frac{1}{72}$ 72. $\frac{1}{73}$ 73. $\frac{1}{74}$ 74. $\frac{1}{75}$ 75. $\frac{1}{76}$ 76. $\frac{1}{77}$ 77. $\frac{1}{78}$ 78. $\frac{1}{79}$ 79. $\frac{1}{80}$ 80. $\frac{1}{81}$ 81. $\frac{1}{82}$ 82. $\frac{1}{83}$ 83. $\frac{1}{84}$ 84. $\frac{1}{85}$ 85. $\frac{1}{86}$ 86. $\frac{1}{87}$ 87. $\frac{1}{88}$ 88. $\frac{1}{89}$ 89. $\frac{1}{90}$ 90. $\frac{1}{91}$ 91. $\frac{1}{92}$ 92. $\frac{1}{93}$ 93. $\frac{1}{94}$ 94. $\frac{1}{95}$ 95. $\frac{1}{96}$ 96. $\frac{1}{97}$ 97. $\frac{1}{98}$ 98. $\frac{1}{99}$ 99. $\frac{1}{100}$ 100. $\frac{1}{101}$ 101. $\frac{1}{102}$ 102. $\frac{1}{103}$ 103. $\frac{1}{104}$ 104. $\frac{1}{105}$ 105. $\frac{1}{106}$ 106. $\frac{1}{107}$ 107. $\frac{1}{108}$ 108. $\frac{1}{109}$ 109. $\frac{1}{110}$ 110. $\frac{1}{111}$ 111. $\frac{1}{112}$ 112. $\frac{1}{113}$ 113. $\frac{1}{114}$ 114. $\frac{1}{115}$ 115. $\frac{1}{116}$ 116. $\frac{1}{117}$ 117. $\frac{1}{118}$ 118. $\frac{1}{119}$ 119. $\frac{1}{120}$ 120. $\frac{1}{121}$ 121. $\frac{1}{122}$ 122. $\frac{1}{123}$ 123. $\frac{1}{124}$ 124. $\frac{1}{125}$ 125. $\frac{1}{126}$ 126. $\frac{1}{127}$ 127. $\frac{1}{128}$ 128. $\frac{1}{129}$ 129. $\frac{1}{130}$ 130. $\frac{1}{131}$ 131. $\frac{1}{132}$ 132. $\frac{1}{133}$ 133. $\frac{1}{134}$ 134. $\frac{1}{135}$ 135. $\frac{1}{136}$ 136. $\frac{1}{137}$ 137. $\frac{1}{138}$ 138. $\frac{1}{139}$ 139. $\frac{1}{140}$ 140. $\frac{1}{141}$ 141. $\frac{1}{142}$ 142. $\frac{1}{143}$ 143. $\frac{1}{144}$ 144. $\frac{1}{145}$ 145. $\frac{1}{146}$ 146. $\frac{1}{147}$ 147. $\frac{1}{148}$ 148. $\frac{1}{149}$ 149. $\frac{1}{150}$ 150. $\frac{1}{151}$ 151. $\frac{1}{152}$ 152. $\frac{1}{153}$ 153. $\frac{1}{154}$ 154. $\frac{1}{155}$ 155. $\frac{1}{156}$ 156. $\frac{1}{157}$ 157. $\frac{1}{158}$ 158. $\frac{1}{159}$ 159. $\frac{1}{160}$ 160. $\frac{1}{161}$ 161. $\frac{1}{162}$ 162. $\frac{1}{163}$ 163. $\frac{1}{164}$ 164. $\frac{1}{165}$ 165. $\frac{1}{166}$ 166. $\frac{1}{167}$ 167. $\frac{1}{168}$ 168. $\frac{1}{169}$ 169. $\frac{1}{170}$ 170. $\frac{1}{171}$ 171. $\frac{1}{172}$ 172. $\frac{1}{173}$ 173. $\frac{1}{174}$ 174. $\frac{1}{175}$ 175. $\frac{1}{176}$ 176. $\frac{1}{177}$ 177. $\frac{1}{178}$ 178. $\frac{1}{179}$ 179. $\frac{1}{180}$ 180. $\frac{1}{181}$ 181. $\frac{1}{182}$ 182. $\frac{1}{183}$ 183. $\frac{1}{184}$ 184. $\frac{1}{185}$ 185. $\frac{1}{186}$ 186. $\frac{1}{187}$ 187. $\frac{1}{188}$ 188. $\frac{1}{189}$ 189. $\frac{1}{190}$ 190. $\frac{1}{191}$ 191. $\frac{1}{192}$ 192. $\frac{1}{193}$ 193. $\frac{1}{194}$ 194. $\frac{1}{195}$ 195. $\frac{1}{196}$ 196. $\frac{1}{197}$ 197. $\frac{1}{198}$ 198. $\frac{1}{199}$ 199. $\frac{1}{200}$ 200. $\frac{1}{201}$ 201. $\frac{1}{202}$ 202. $\frac{1}{203}$ 203. $\frac{1}{204}$ 204. $\frac{1}{205}$ 205. $\frac{1}{206}$ 206. $\frac{1}{207}$ 207. $\frac{1}{208}$ 208. $\frac{1}{209}$ 209. $\frac{1}{210}$ 210. $\frac{1}{211}$ 211. $\frac{1}{212}$ 212. $\frac{1}{213}$ 213. $\frac{1}{214}$ 214. $\frac{1}{215}$ 215. $\frac{1}{216}$ 216. $\frac{1}{217}$ 217. $\frac{1}{218}$ 218. $\frac{1}{219}$ 219. $\frac{1}{220}$ 220. $\frac{1}{221}$ 221. $\frac{1}{222}$ 222. $\frac{1}{223}$ 223. $\frac{1}{224}$ 224. $\frac{1}{225}$ 225. $\frac{1}{226}$ 226. $\frac{1}{227}$ 227. $\frac{1}{228}$ 228. $\frac{1}{229}$ 229. $\frac{1}{230}$ 230. $\frac{1}{231}$ 231. $\frac{1}{232}$ 232. $\frac{1}{233}$ 233. $\frac{1}{234}$ 234. $\frac{1}{235}$ 235. $\frac{1}{236}$ 236. $\frac{1}{237}$ 237. $\frac{1}{238}$ 238. $\frac{1}{239}$ 239. $\frac{1}{240}$ 240

that connections are made between the access path interface unit in the channel interface package and the access path interface unit in each of the plural memory

packages, and between the access path interface unit in the disk interface package and the access path interface unit in each of the plural memory packages by cables.

3. (Amended) The disk array controller as defined in claim 2, characterized in that the plural memory packages are interconnected by cables.

4. (Amended) The disk array controller as defined in claim 2, characterized in that the memory units packaged in the plural memory packages store the same data.

5. (Amended) The disk array controller as defined in claim 2, characterized in that power is supplied from different power supplies to the plural memory packages.

6. (Amended) The disk array controller as defined in claim 1, characterized in that the channel interface package and the disk interface package are mounted on a platter.

7. (Amended) The disk array controller as defined in claim 1, characterized in that the channel interface package and the disk interface package are mounted on different platters.

8. A disk array controller, characterized in that it comprises:

an interface package in which at least a channel interface unit with a host computer and an access path interface unit are packaged;

NOV 14 1989

1944

a disk interface package in which at least a disk interface with a disk drive and an access path interface unit are packaged; and

a cache memory package in which a cache memory unit for temporarily storing data to be recorded into the disk drive and an access path interface unit are packaged, and

that connections are made between the access path interface unit in the channel interface package and the access path interface unit in the cache memory package and between the access path interface unit in the disk interface package and the access path interface unit in the cache memory package by cables.

9. (Amended) The disk array controller as defined in claim 8, characterized in that it has plural said cache memory packages and

that connections are made between the access path interface unit in the channel interface package and the access path interface unit in each of the plural cache memory packages and between the access path interface unit in the disk interface package and the access path interface unit in each of the plural memory packages by cables.

10. (Amended) The disk array controller as defined in claim 9, characterized in that the plural cache memory packages are interconnected by cables.

11. (Amended) The disk array controller as defined in claim 9, characterized in that the cache memory units mounted in the plural cache memory packages store the same data.

12. (Amended) The disk array controller as defined in claim 9, characterized in that power is supplied from different power supplies to the plural cache memory packages.

13. A disk array controller, characterized in that it comprises:

an interface platter on which a channel interface unit to be connected with a host computer and a disk interface unit to be connected with a disk drive are mounted;

a memory platter on which a memory unit for storing control data for the disk drive is mounted;

a cable which connects the interface platter and the memory platter; and

a selector unit, connected with the channel interface unit, the disk interface unit and the memory unit, which selects requests from the channel interface unit and the disk interface unit.

14. The disk array controller as defined in claim 13, characterized in that the selector unit is mounted on the interface platter.

15. The disk array controller as defined in claim 14, characterized in that the selector unit and the memory unit are connected.

COPIES TO BE MADE OF THIS DOCUMENT

[illegible]

18. A disk array controller, characterized in that it comprises:

a memory platter on which a cache memory unit for storing data to be recorded into the disk drive is mounted;

a selector unit, connected with the channel interface unit, the disk interface unit and the cache memory unit, which selects requests from the channel interface unit and the disk interface unit.

20. The disk array controller as defined in claim 19,
characterized in that the selector unit and the memory unit
are connected.

21. The disk array controller as defined in claim 19, characterized in that the selector unit is mounted on the reverse of the surface on which the channel interface unit and the disk interface unit are mounted.

22. A disk array controller, characterized in that it comprises:

plural platters on each of which a channel interface unit to be connected with a host computer, a disk interface to be connected with a disk drive and a memory unit for storing control data for the disk drive are mounted; and a cable which interconnects the plural platters;

23. The disk array controller as defined in claim 22, characterized in that the cables include a cable which connects the channel interface unit or the disk interface unit on one of the plural platters, with the memory unit on another one of the plural platters.

24 (Amended) The disk array controller as defined in claim 22, characterized in that it has a selector unit, connected with the channel interface unit, the disk interface unit and the memory unit which are mounted on one of the plural platters, which selects requests from the channel interface unit and the disk interface unit.

25. The disk array controller as defined in claim 24, characterized in that the selector unit is mounted on the platter.

[illegible]

a selector unit, connected with the channel interface unit, the disk interface unit and the cache memory unit which are mounted on one of the plural platters, which selects requests from the channel interface unit and the disk interface unit.

30. A disk array controller, characterized in that it comprises:

a cable which connects the second and third platters.

THE UNIVERSITY OF CHICAGO

ATTN: 1001

31. The disk array controller as defined in claim 30, characterized in that it has:

a fourth platter on which a cache memory unit for storing data to be recorded into the disk drive is mounted;

a cable which connects the first and fourth platters; and

a cable which connects the second and fourth platters.

32. (Deleted)

33. (Deleted)

34. (Deleted)

35. (Deleted)

36. (Amended) A disk array controller, characterized in that it comprises:

an interface platter on which a channel interface to be connected with a host computer and a disk interface unit to be connected with a disk drive are mounted; and

a memory platter on which a memory unit for storing control data for the disk drive is mounted,

wherein the interface platter is perpendicular to the memory platter.

37. A disk array controller, characterized in that it comprises:

plural interface platters on each of which a channel interface unit to be connected with a host computer and a

COPIES OF THIS DOCUMENT ARE AVAILABLE FROM THE NATIONAL ARCHIVES AT COLLEGE PARK, MARYLAND

1-34
1307

disk interface unit to be connected with a disk drive are mounted; and

a memory platter on which a memory unit for storing control data for the disk drive is mounted,

wherein the memory platter is located between the plural interface platters.

38. A disk array controller, characterized in that it comprises:

plural platters on each of which a channel interface unit to be connected with a host computer, a disk interface unit to be connected with a disk drive and a memory unit for storing control data for the disk drive are mounted,

wherein one of the plural platters is located above another one of the plural platters.

39. The disk array controller as defined in claim 38, characterized in that said one platter and said other platter are vertical.

40. (Deleted)

41. (Amended) A disk array controller, characterized in that it comprises:

an interface platter on which a channel interface unit to be connected with a host computer and a disk interface unit to be connected with a disk drive are mounted; and

a memory platter on which a cache memory unit for storing data to be recorded into the disk drive is mounted,

RECEIVED
FEB 14 1984
FBI - NEW YORK

wherein the interface platter is perpendicular to the memory platter.

42. A disk array controller, characterized in that it comprises:

plural interface platters on each of which a channel interface to be connected with a host computer and a disk interface to be connected with a disk drive are mounted; and

a memory platter on which a cache memory unit for storing data to be recorded into the disk drive is mounted,

wherein the memory platter is located between the plural interface platters.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
219

Abstract

This invention relates to a disk array controller. There has been demand for a large scale memory device system operable without interruption. Further, in order to cope with the recent trend toward open systems, scalability of performance and capacity in such systems is needed.

Conventionally, internal buses such as ones which connect the channel interface section to the shared memory section, and the disk interface section to the shared memory section, have been mounted on one platter, and the channel interface and other packages have been mounted thereon. If the internal buses have failed, the operation of the whole system must be stopped. There has been another problem that the performance of the internal buses is fixed.

A disk array controller according to this invention comprises an interface platter on which a channel interface section and a disk interface section are mounted, a memory platter on which a shared memory section is mounted, and a cable which connects the interface platter to the memory platter in order to solve the above problems.

1/83

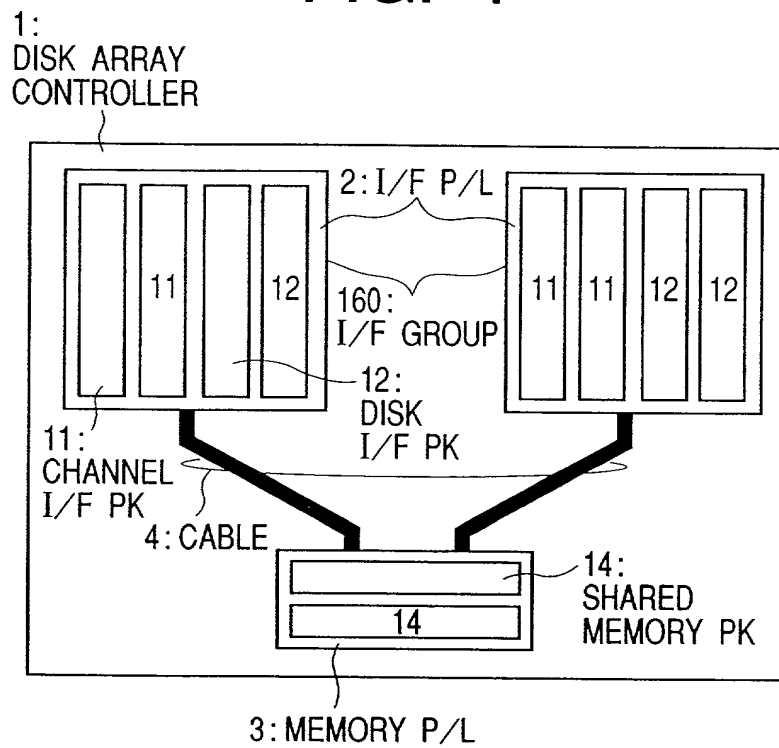
FIG. 1

FIG. 2

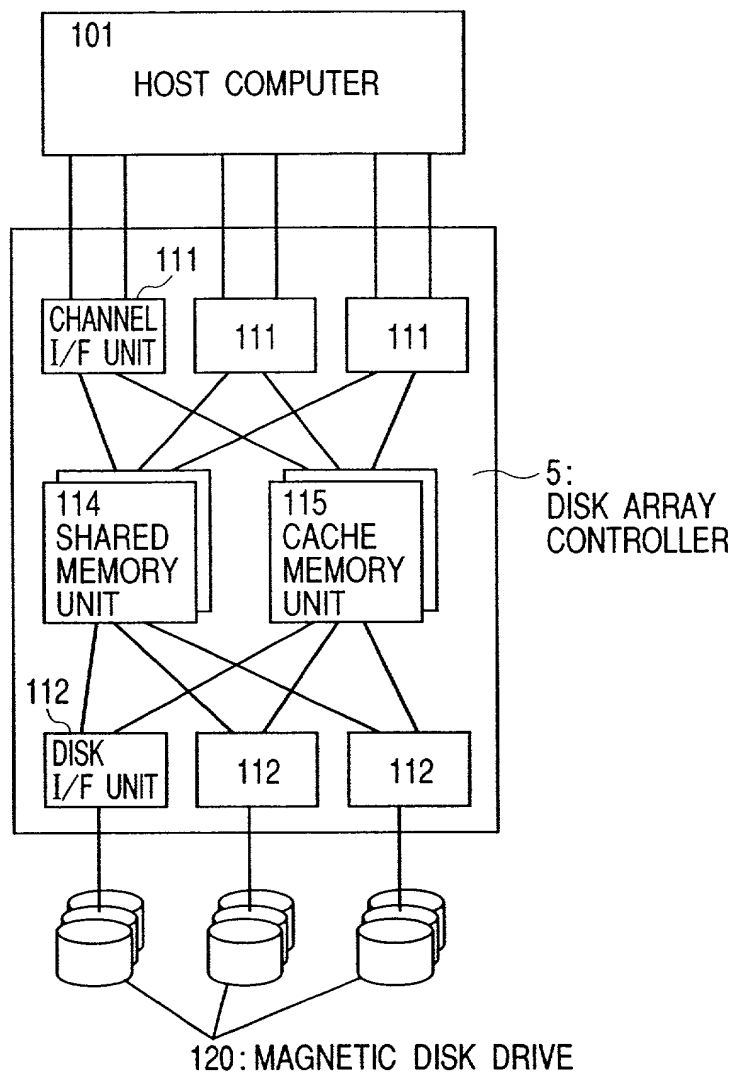


FIG. 3

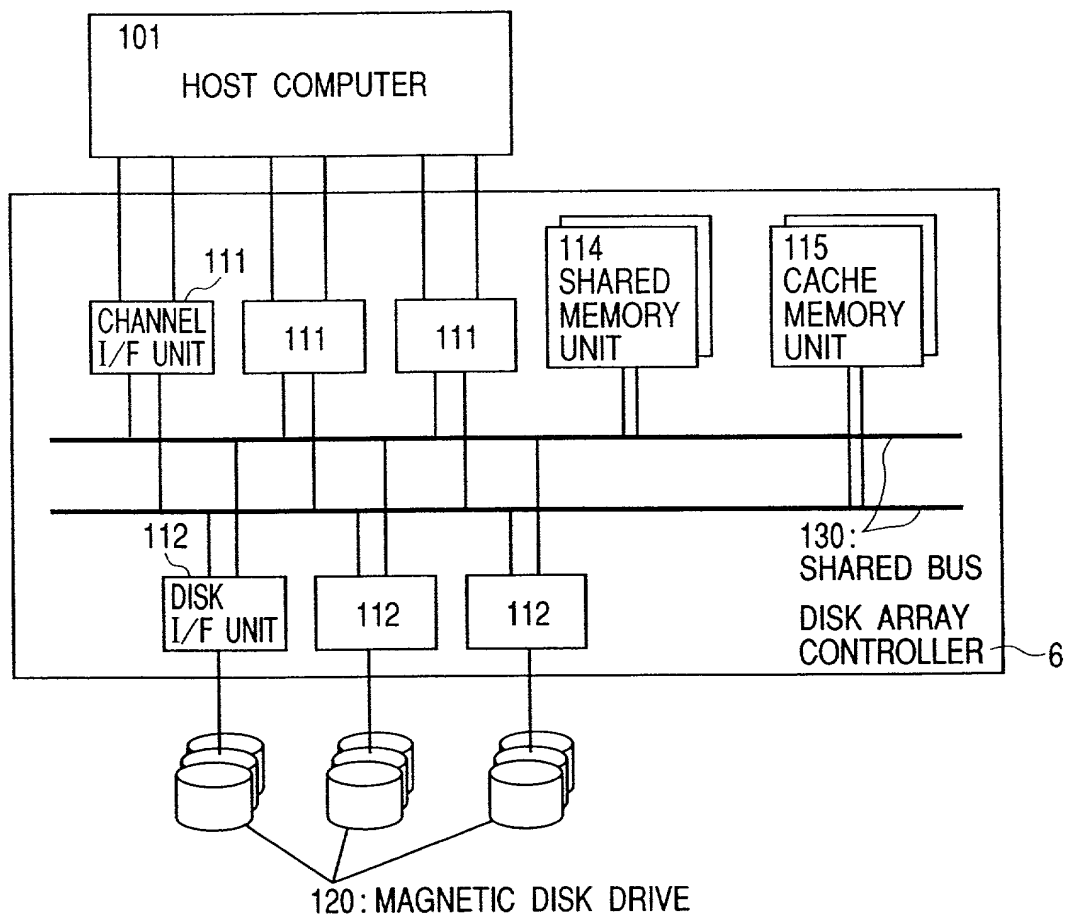
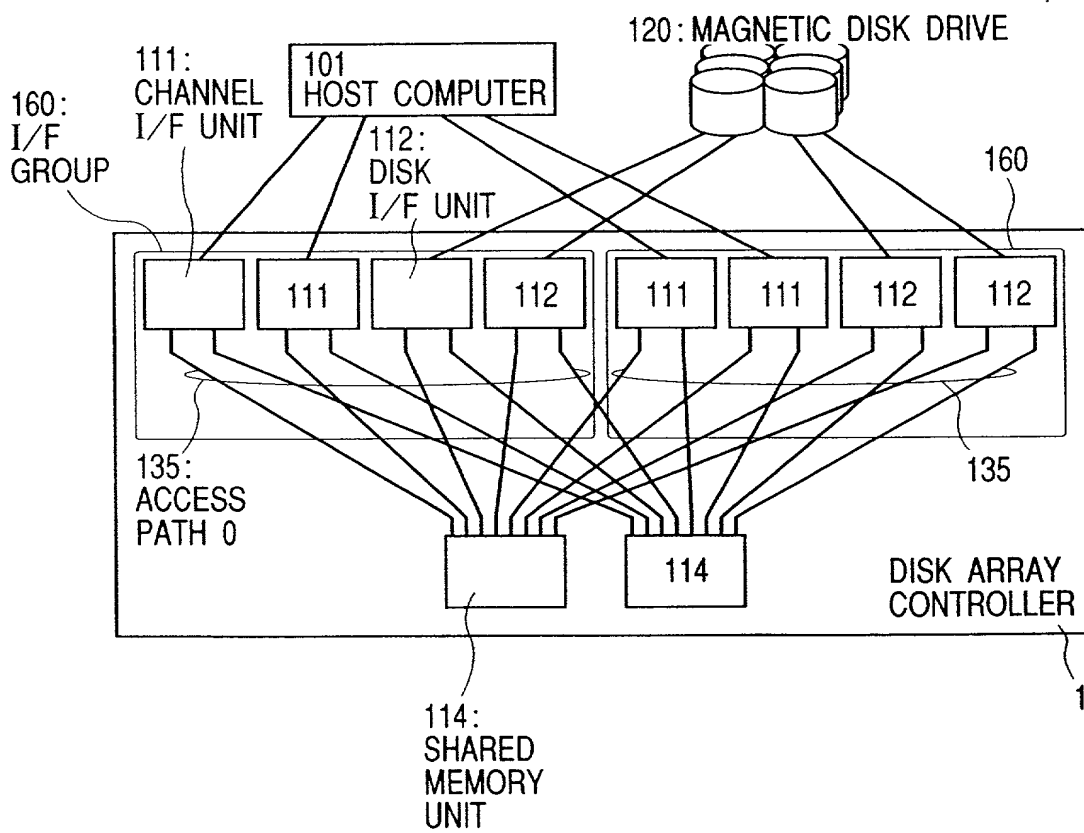


FIG. 4



5/83

FIG. 5

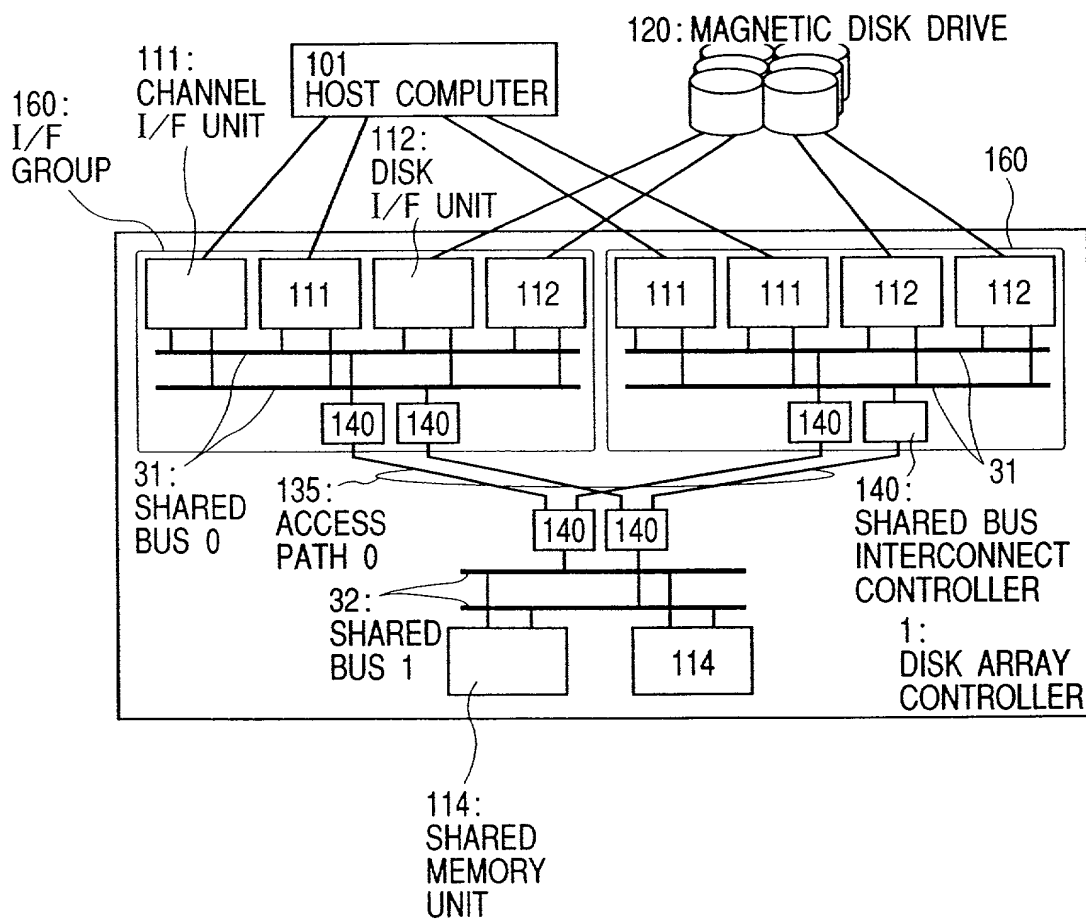


FIG. 6

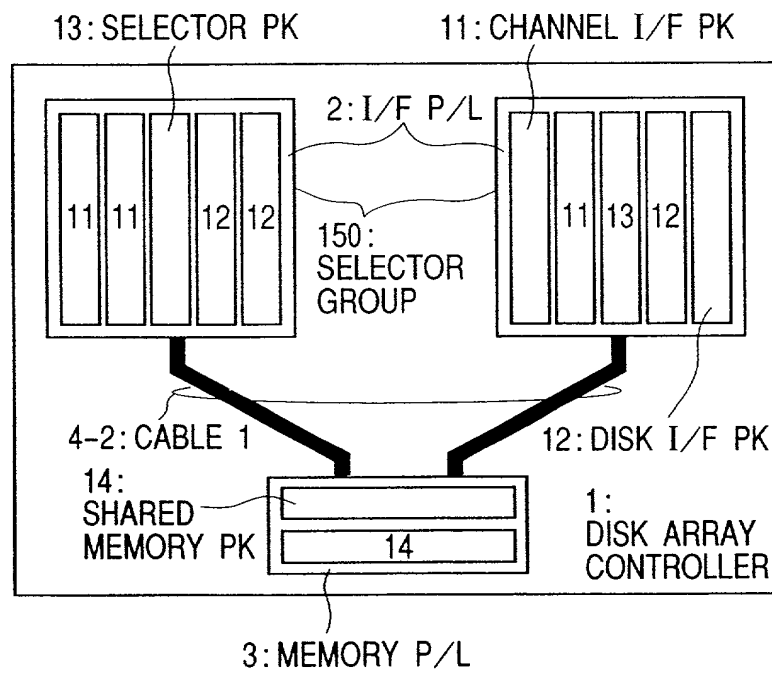


FIG. 7

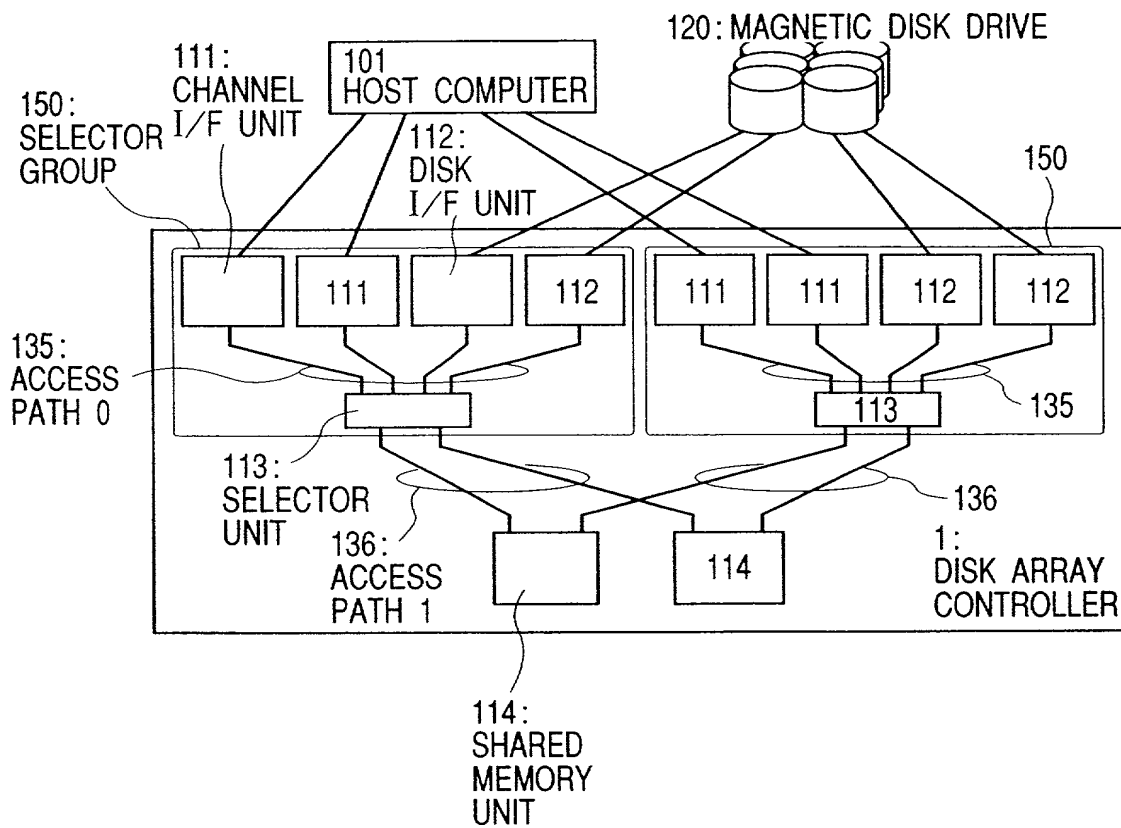
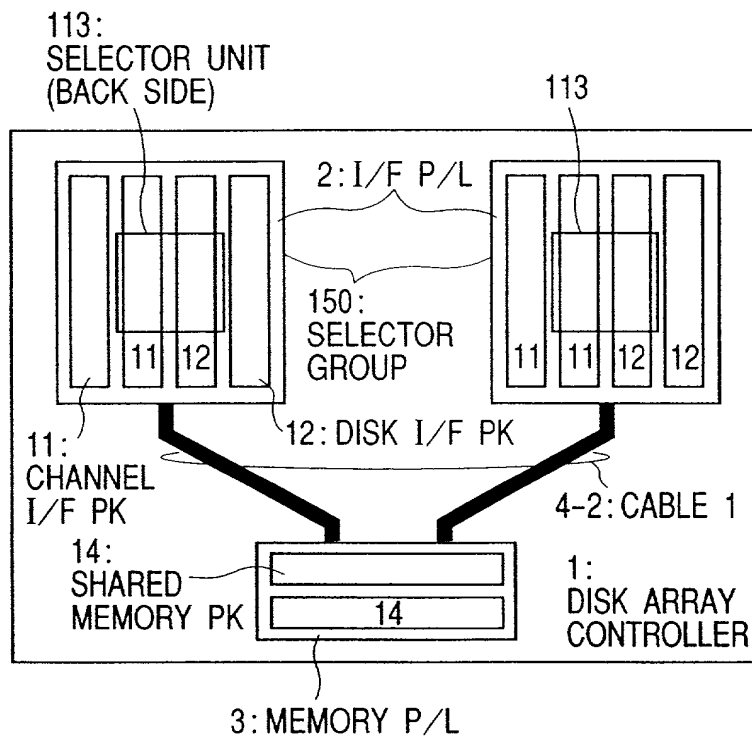


FIG. 8



9/83

FIG. 9

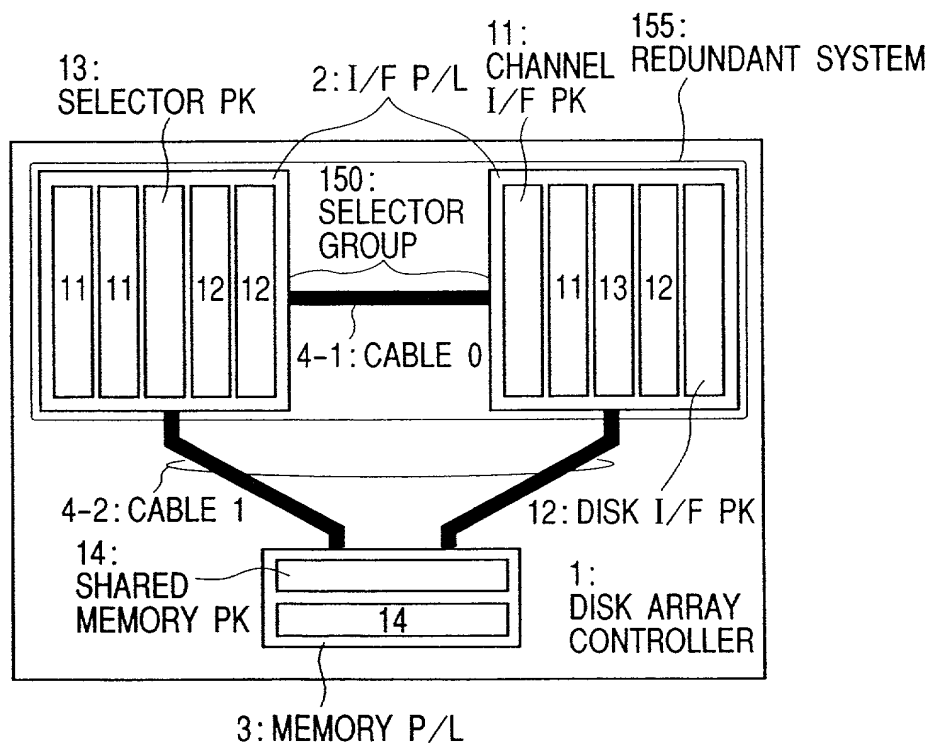
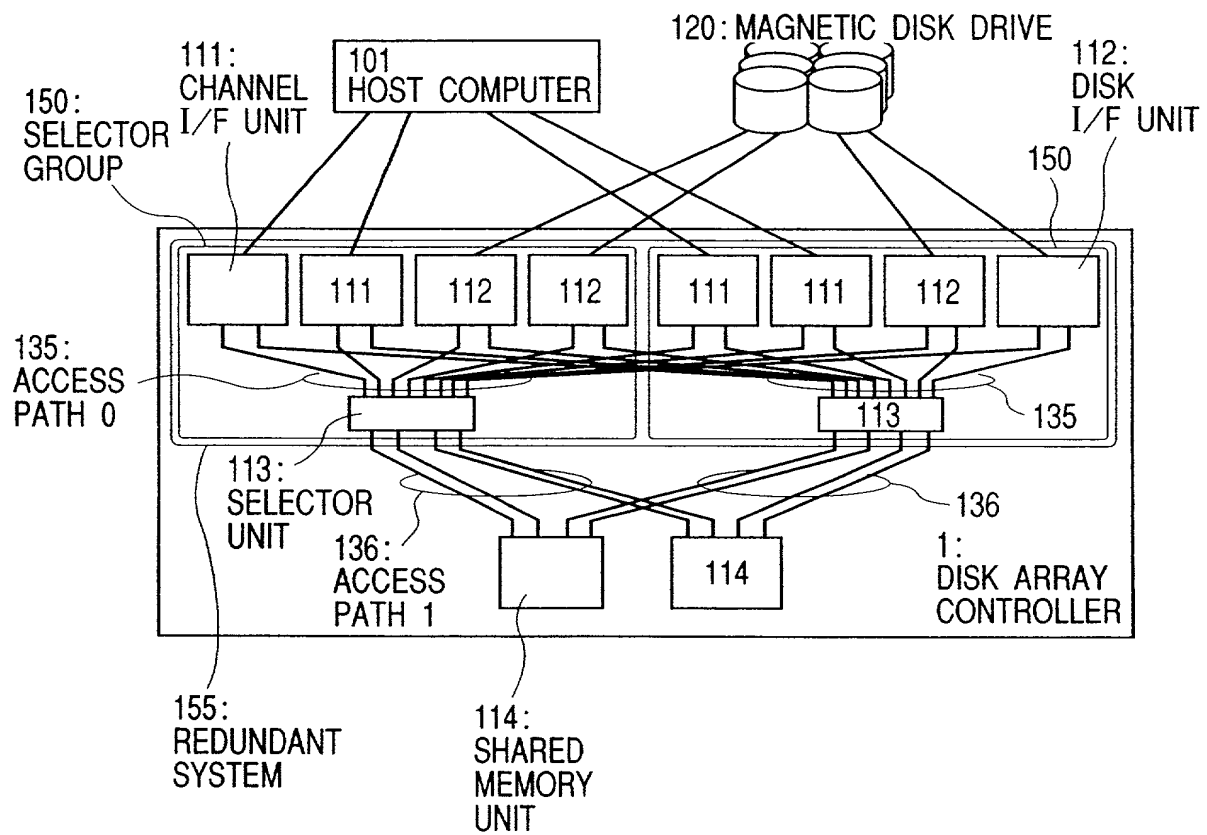
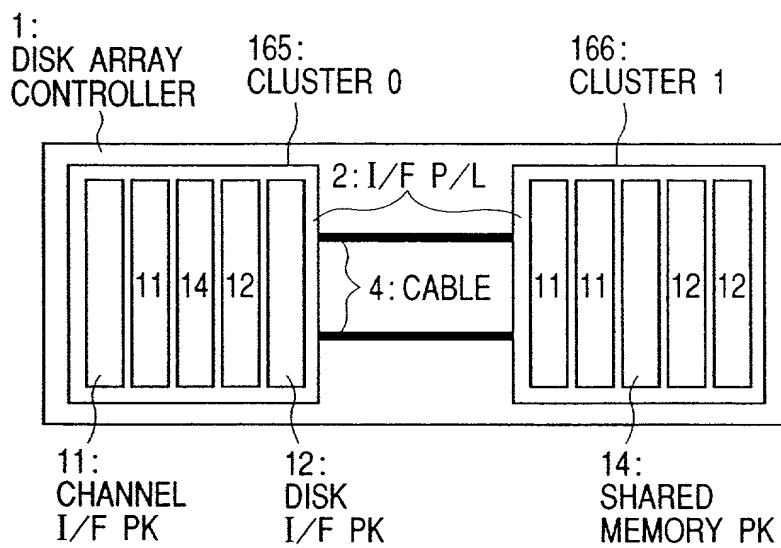


FIG. 10



11/83

FIG. 11



12/83

FIG. 12

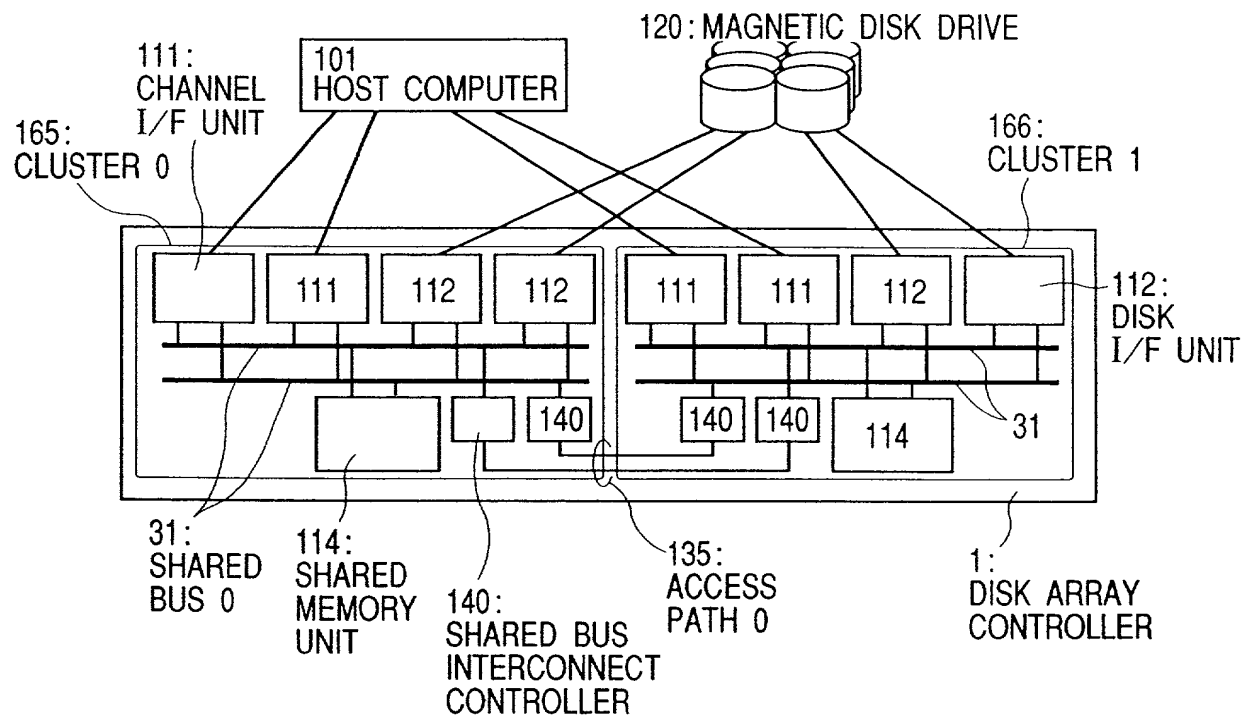


FIG. 13

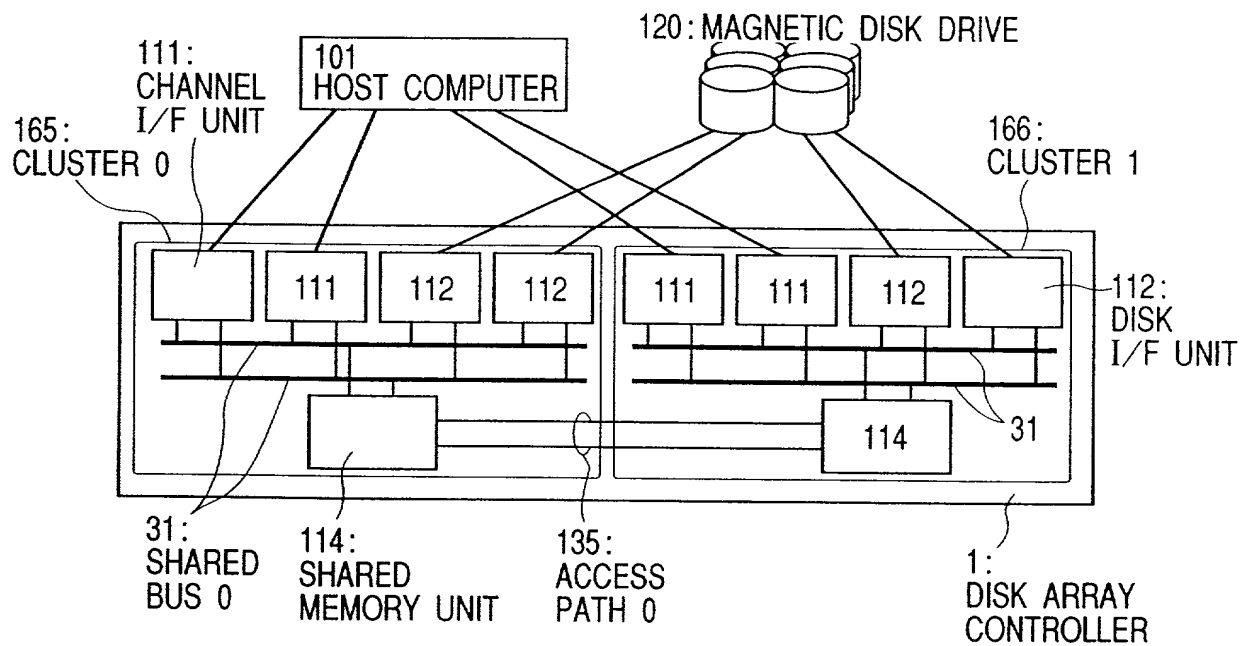
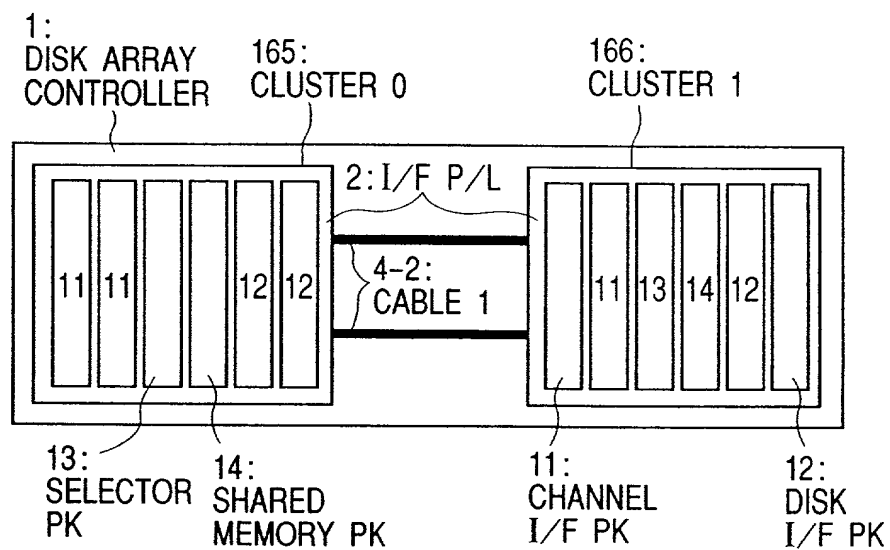
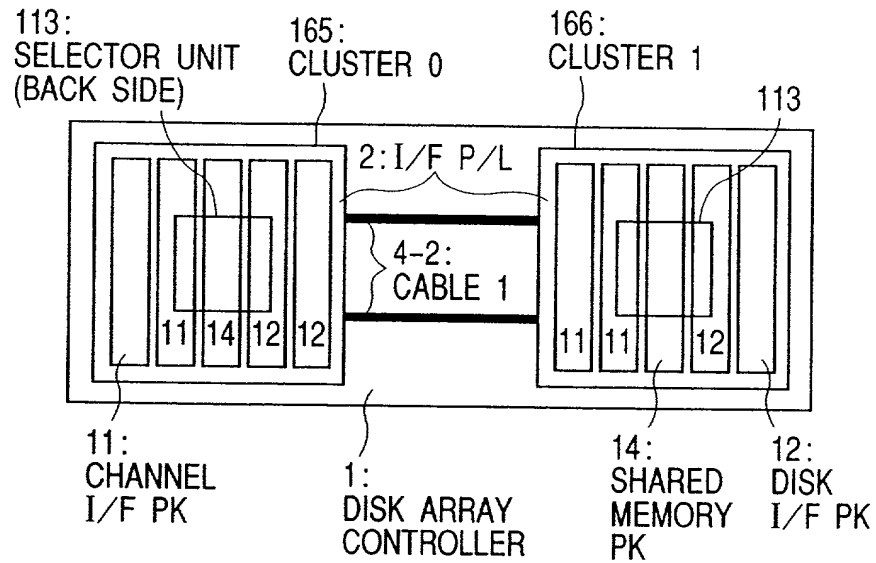


FIG. 14



15/83

FIG. 15

16/83

FIG. 16

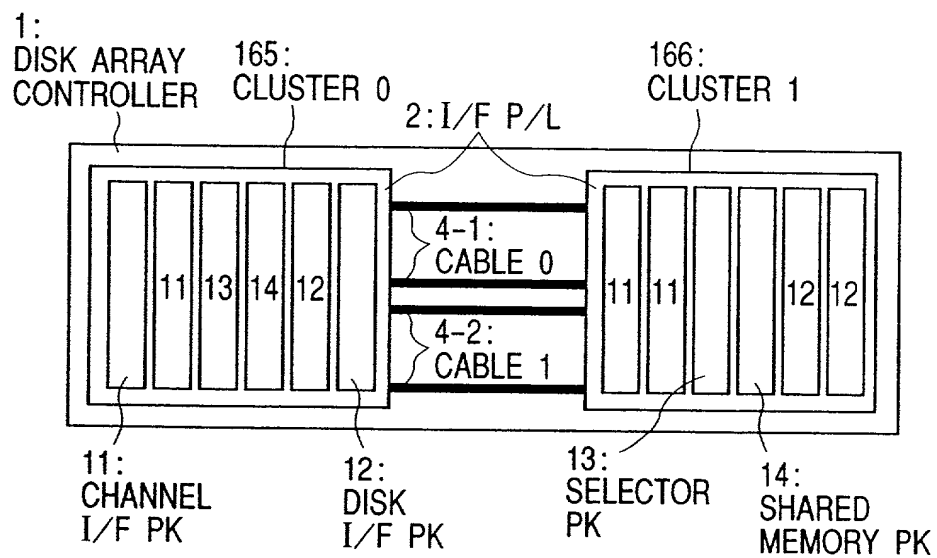


FIG. 17

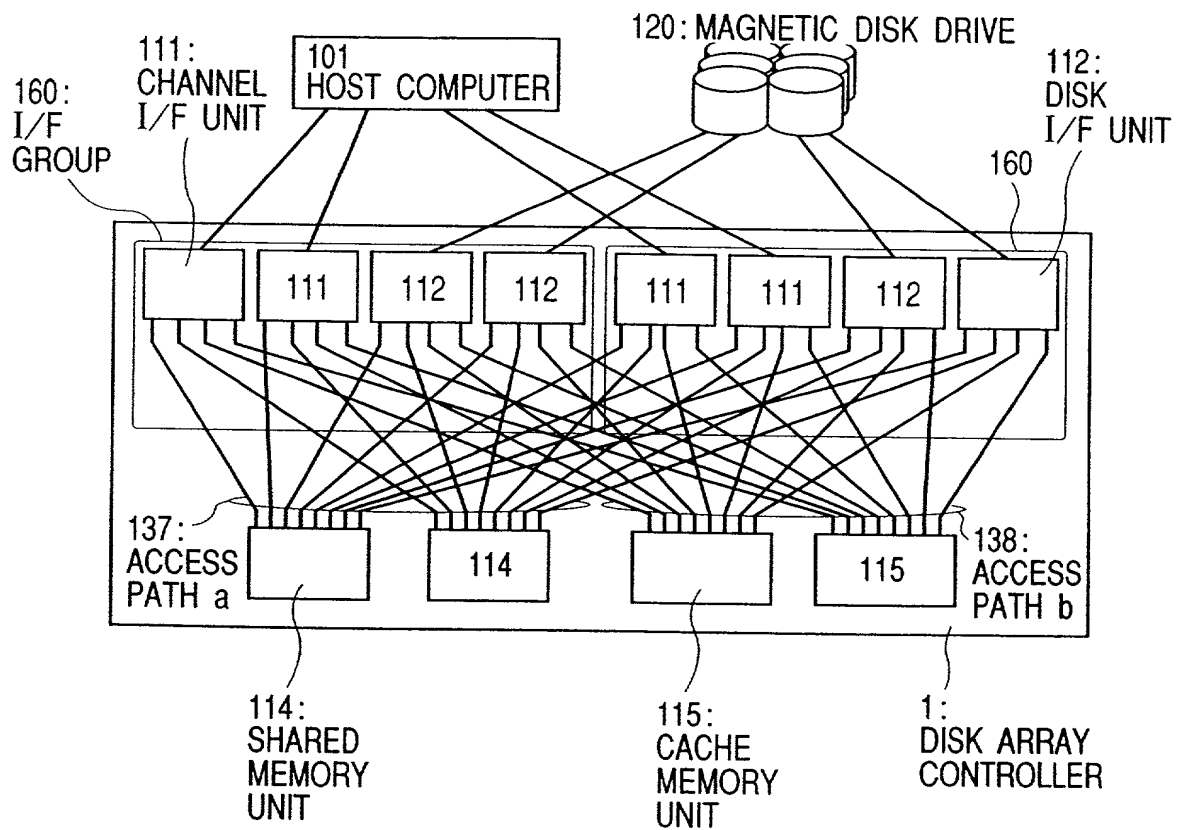


FIG. 18

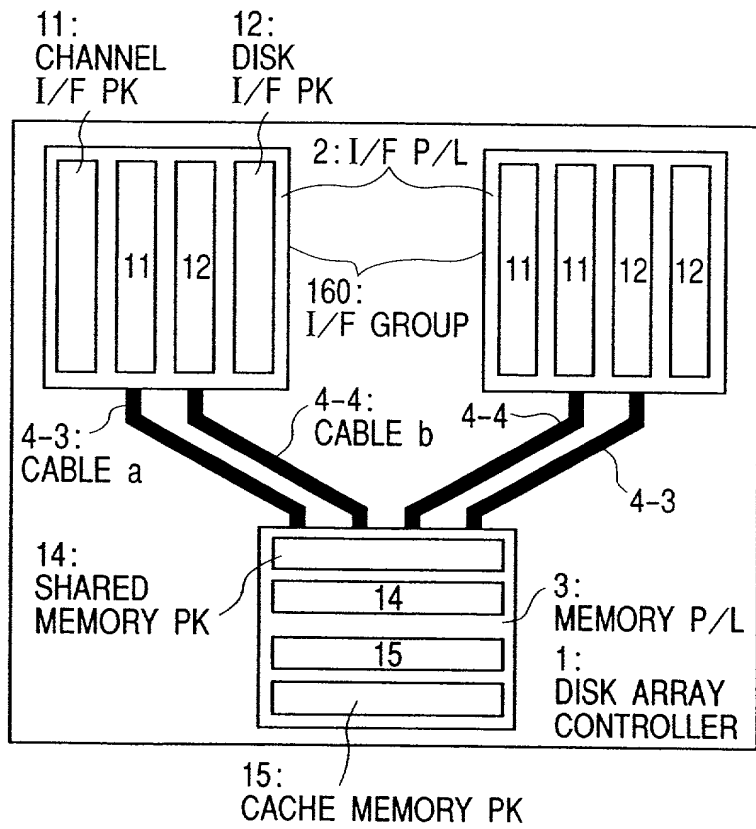


FIG. 19

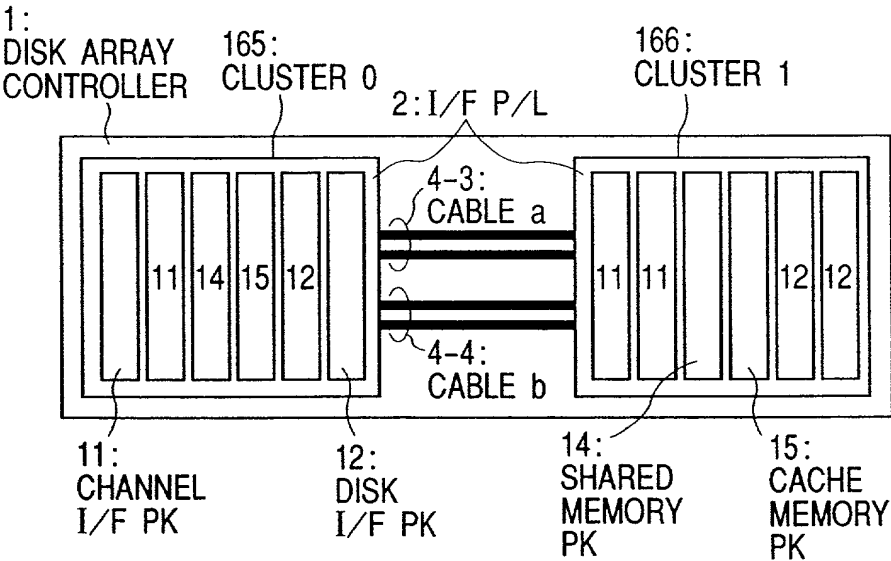
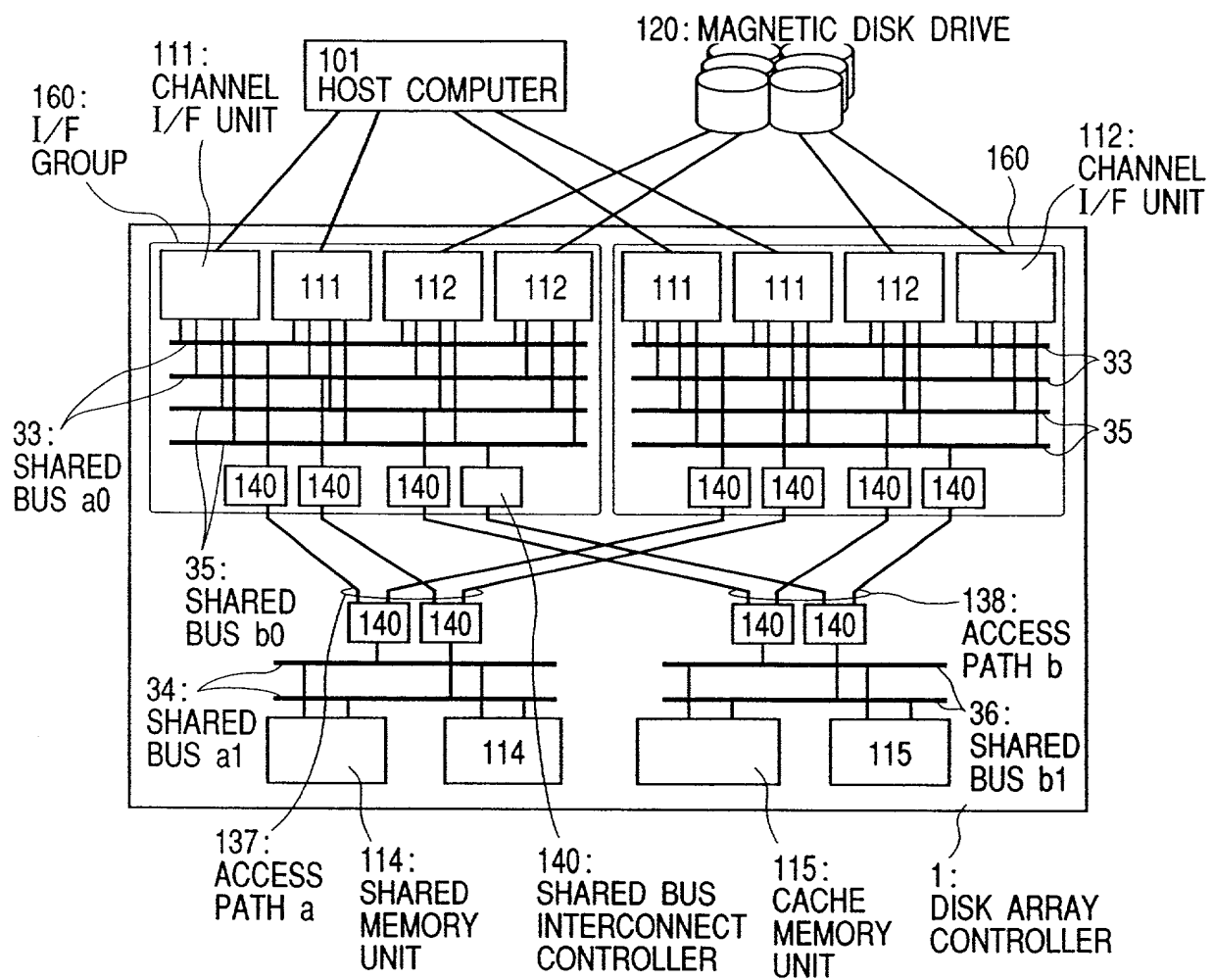


FIG. 20



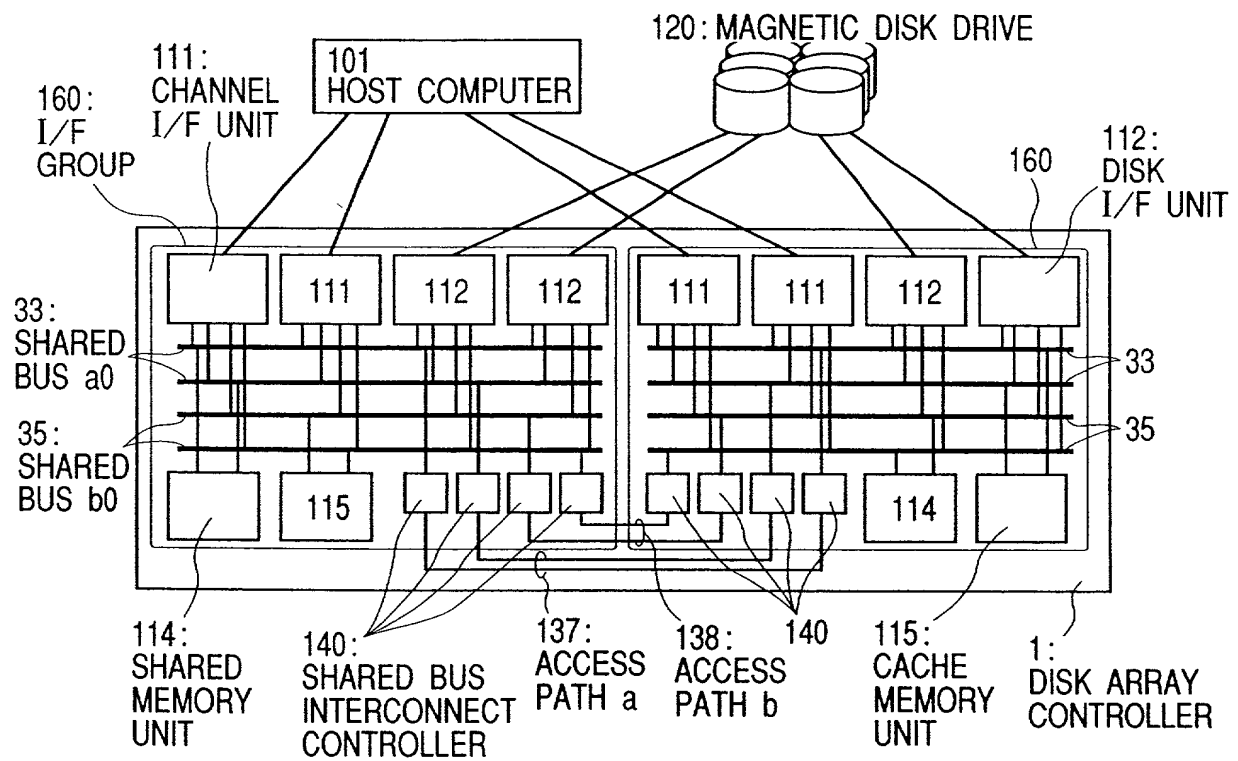


FIG. 22

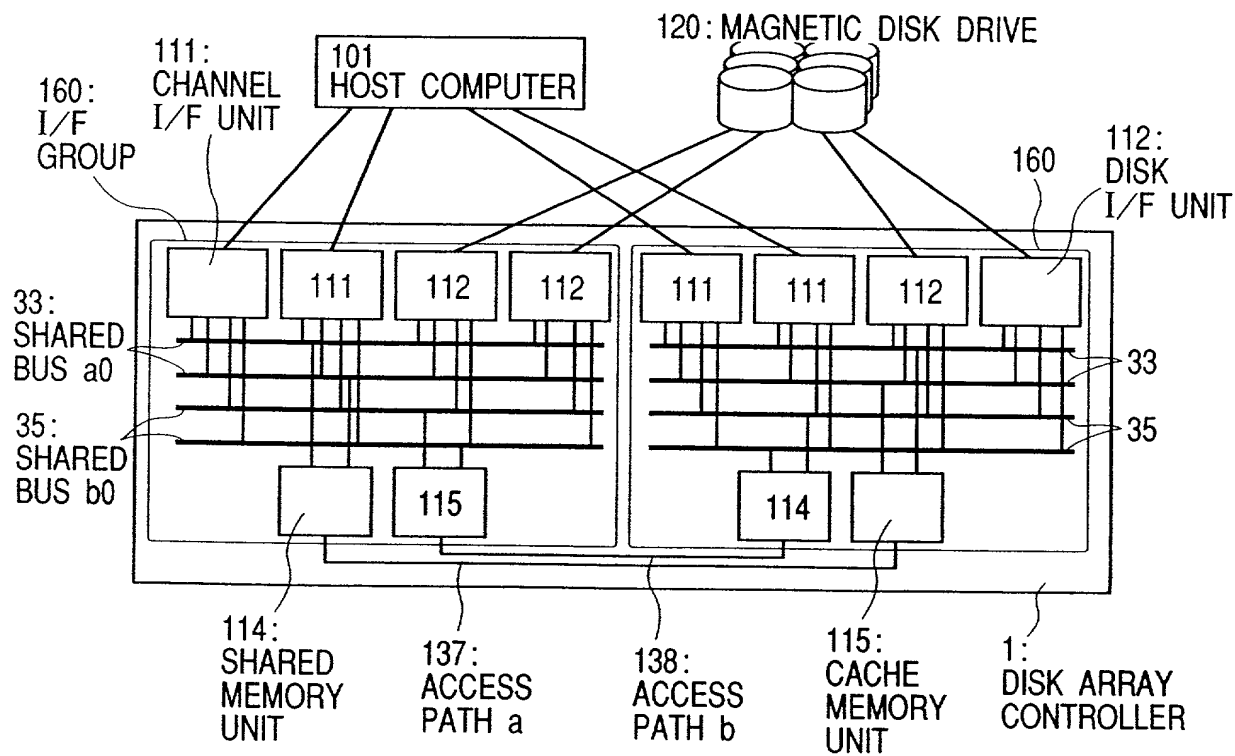
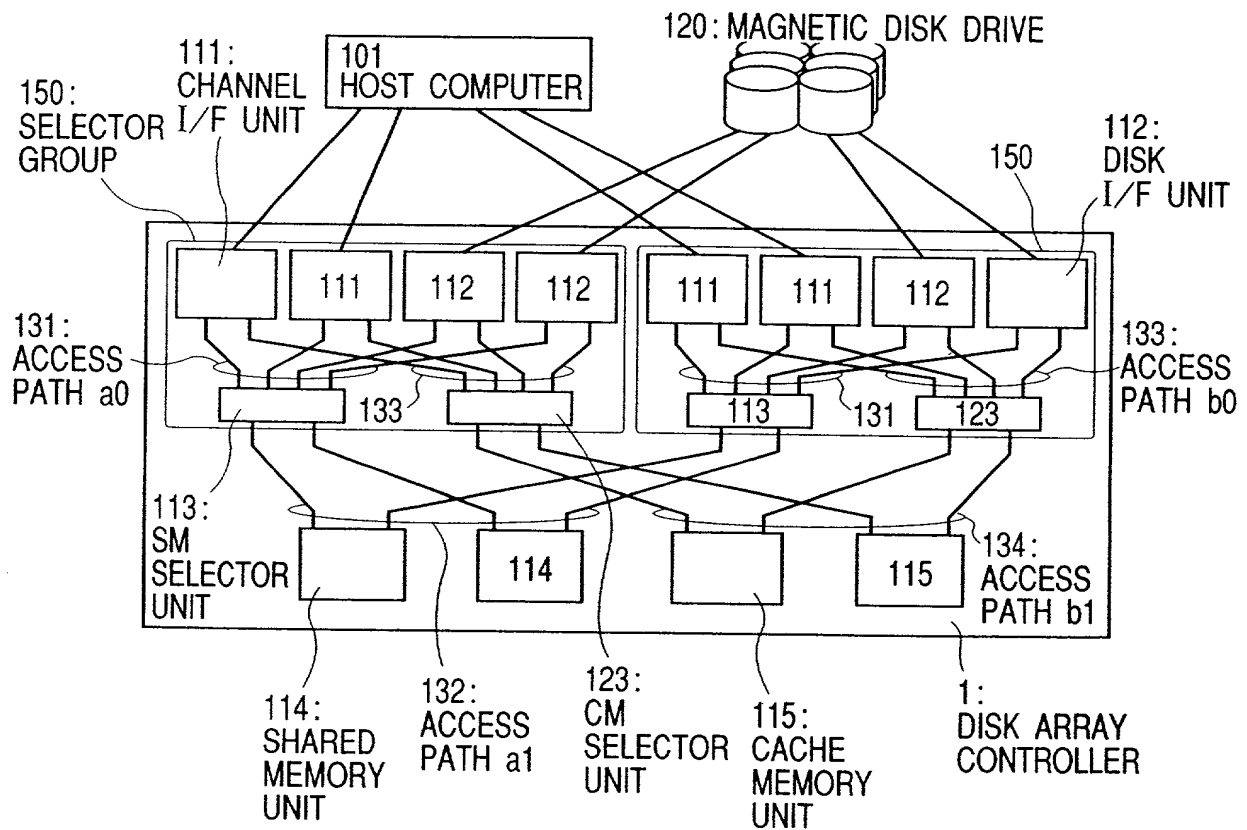
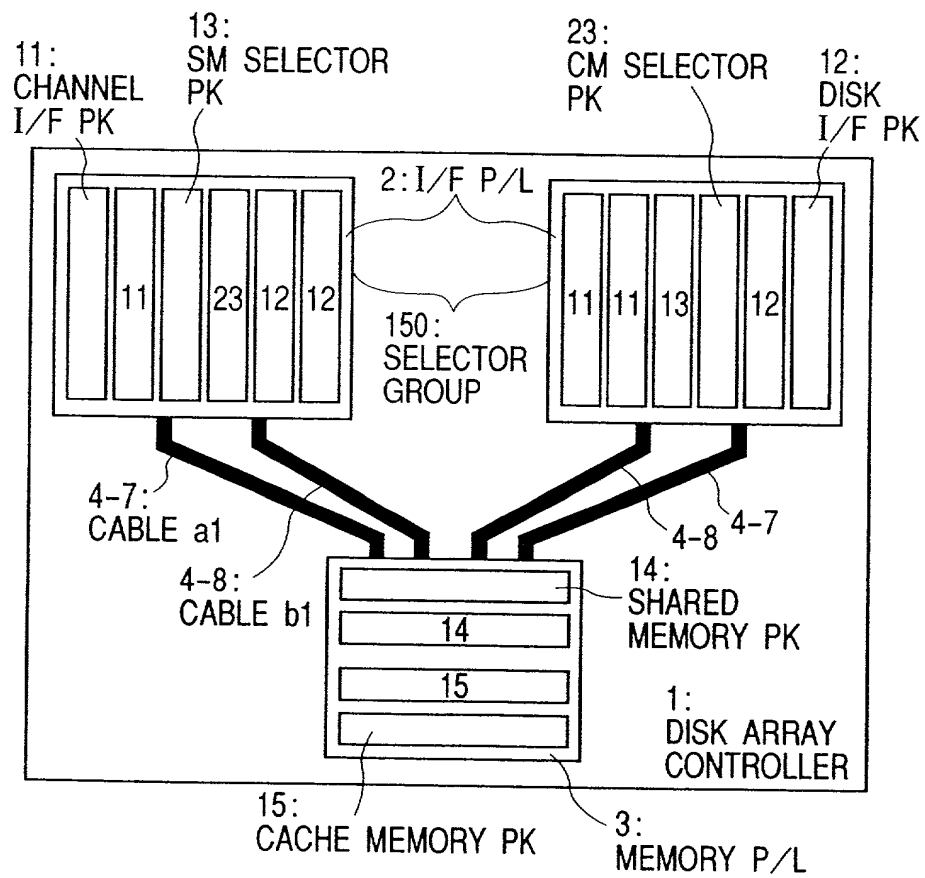


FIG. 23



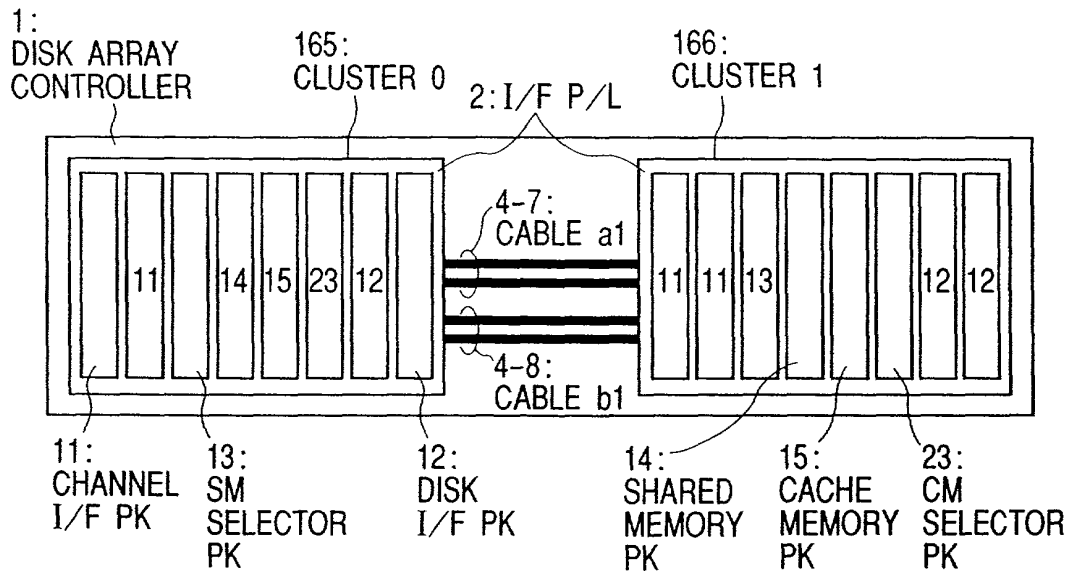
24/83

FIG. 24



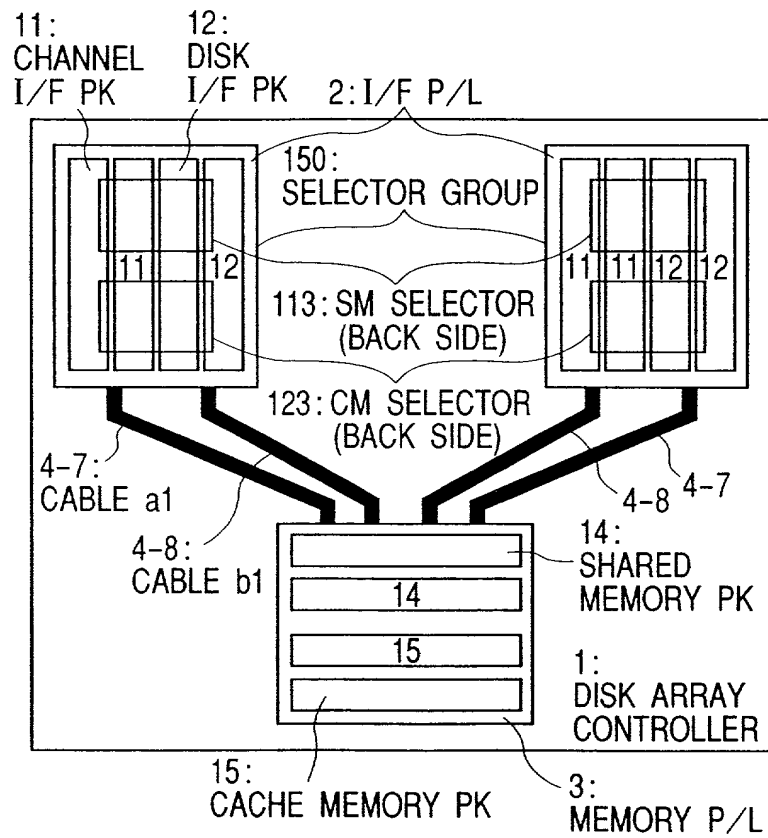
25 / 83

FIG. 25



26/83

FIG. 26



27/83

FIG. 27

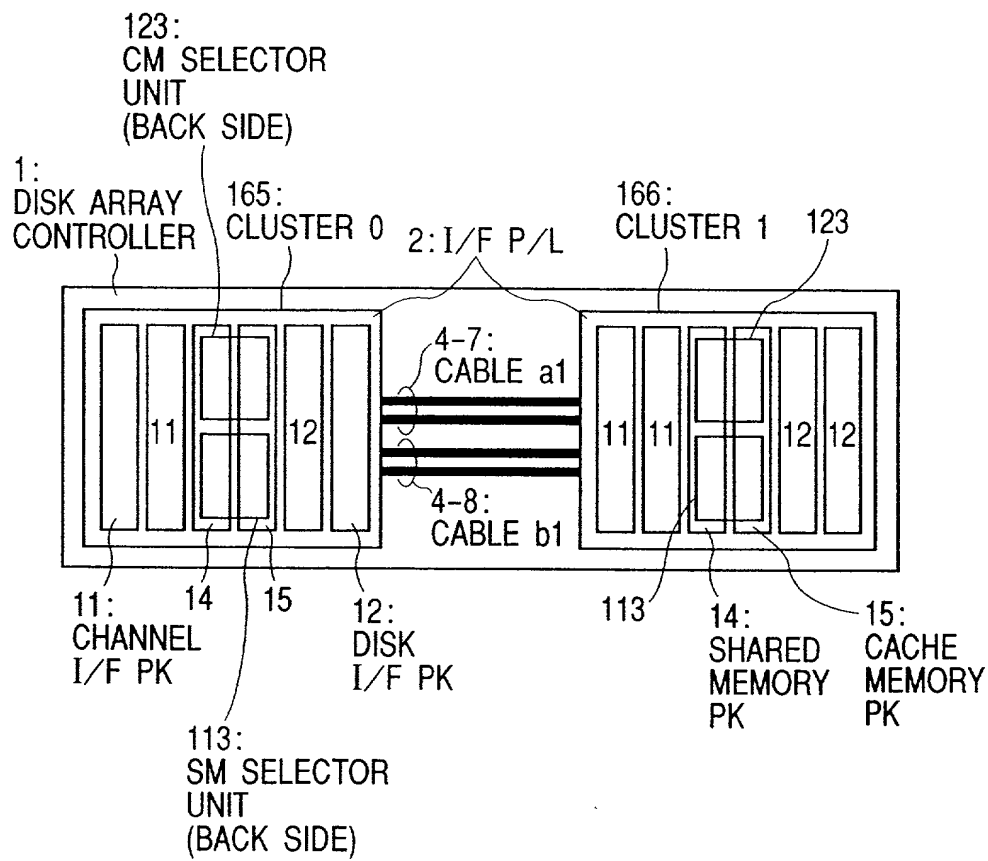


FIG. 28

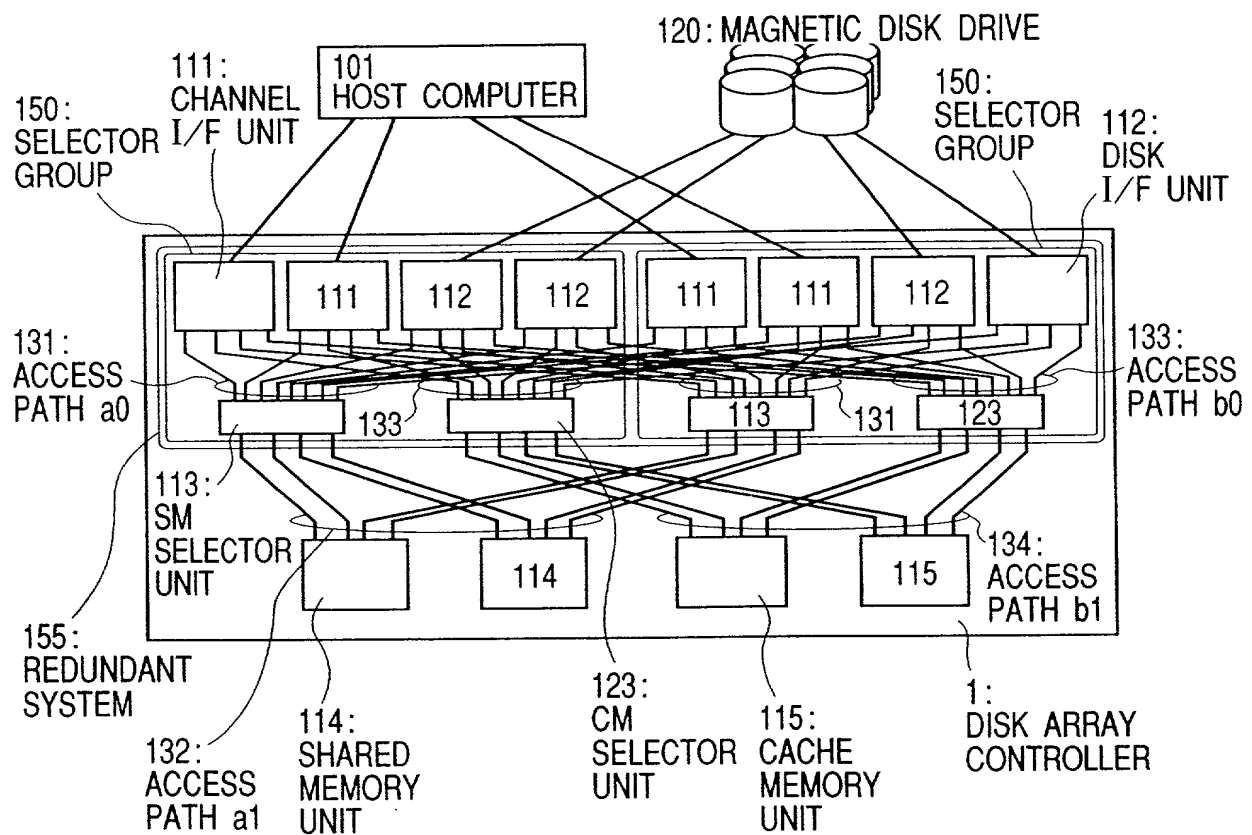


FIG. 29

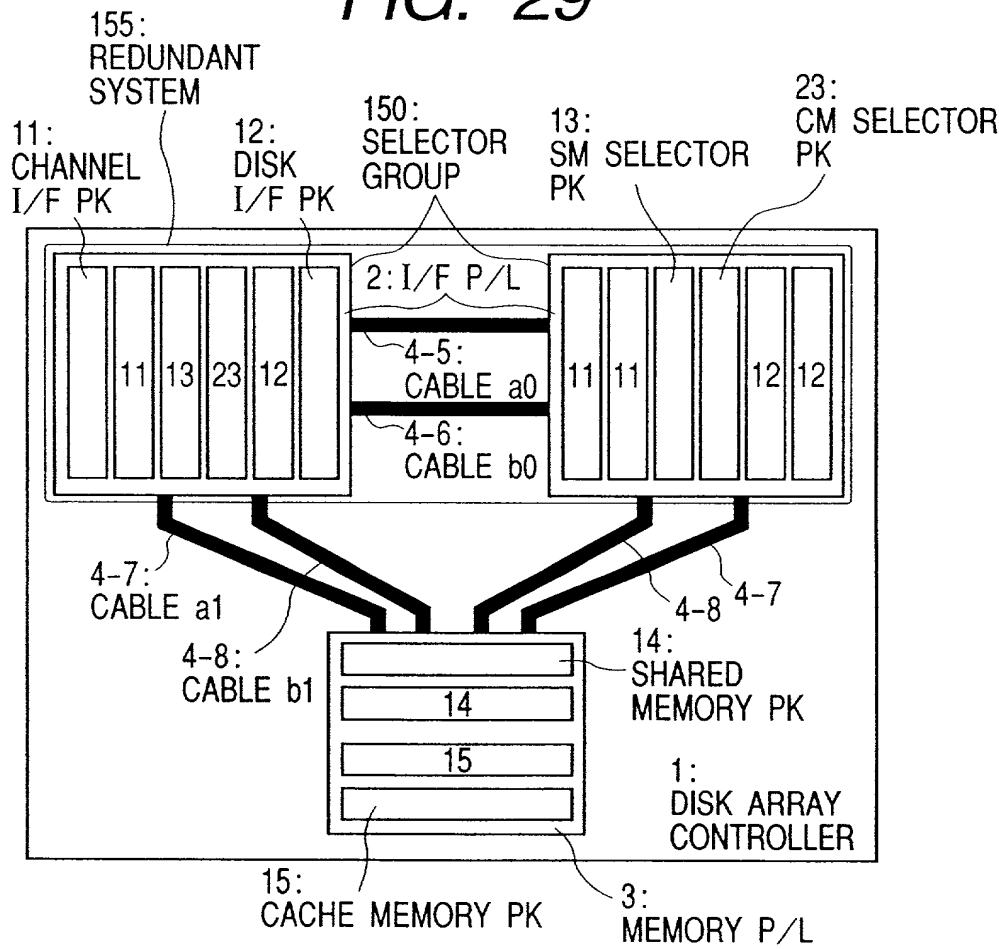


FIG. 30

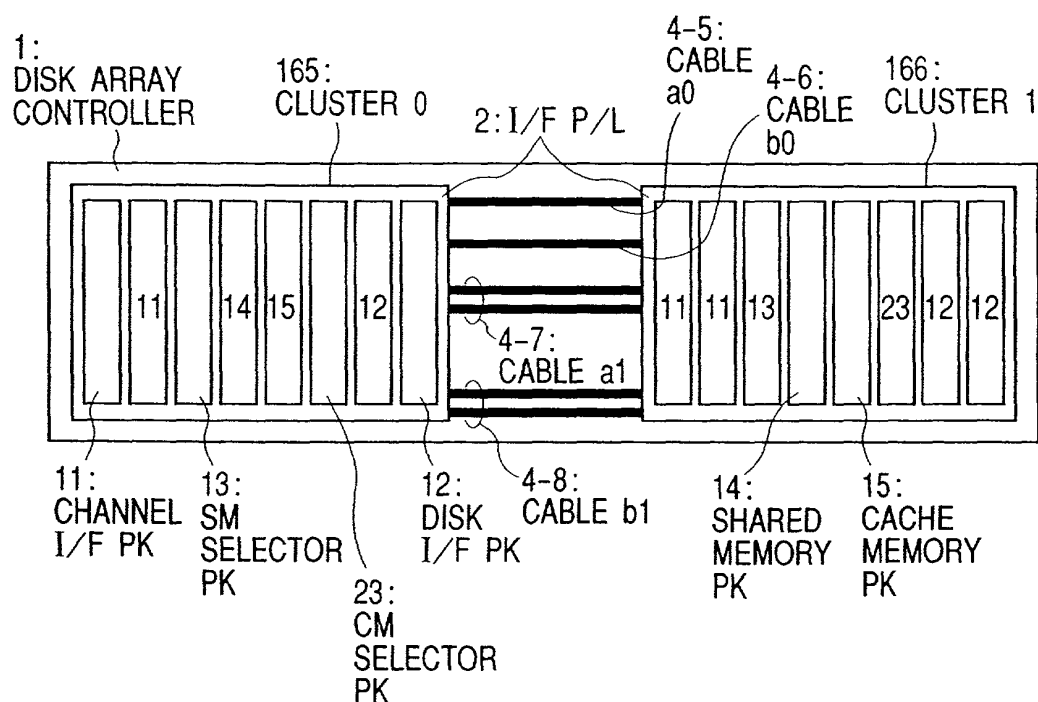


FIG. 31

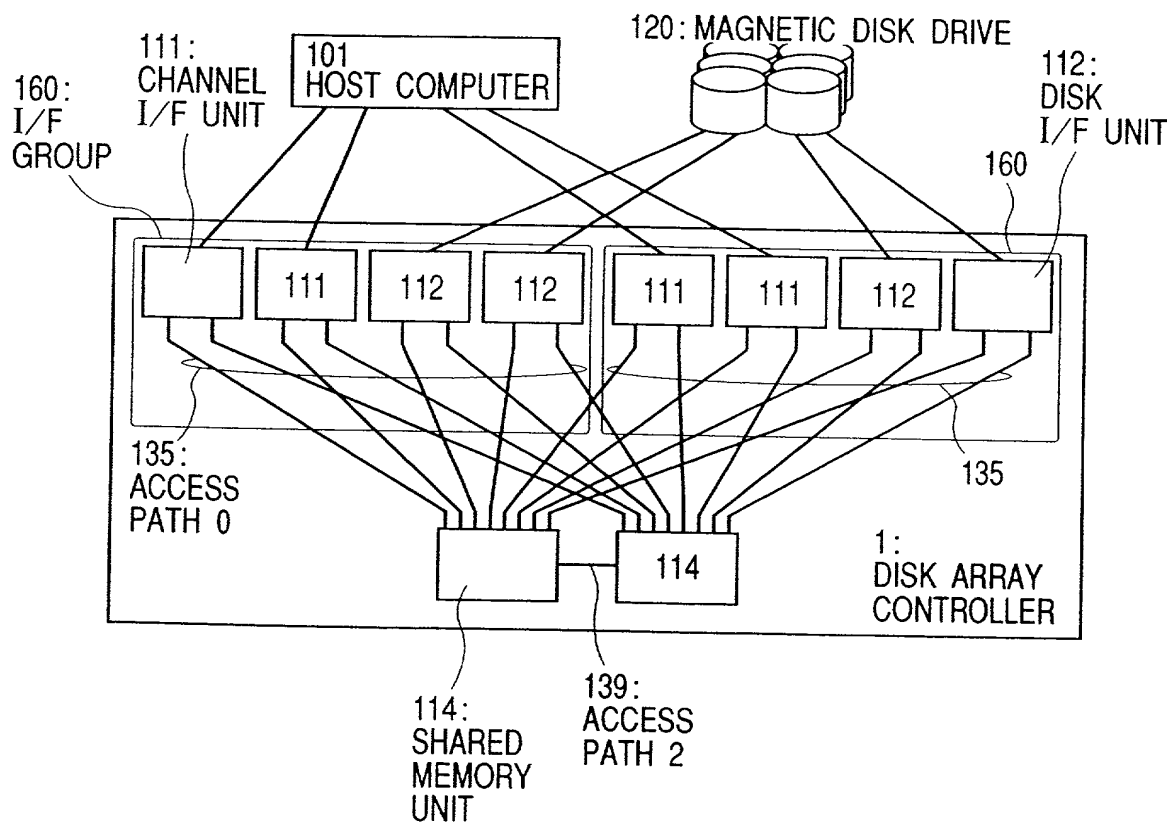
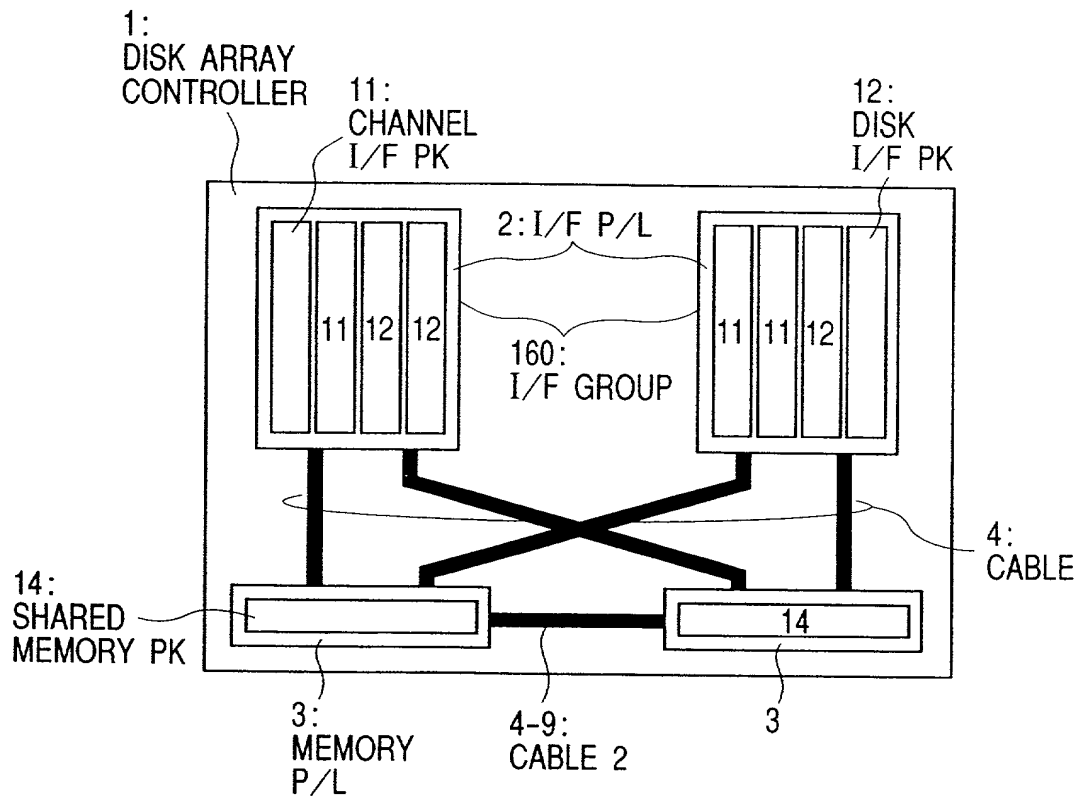


FIG. 32



33/83

FIG. 33

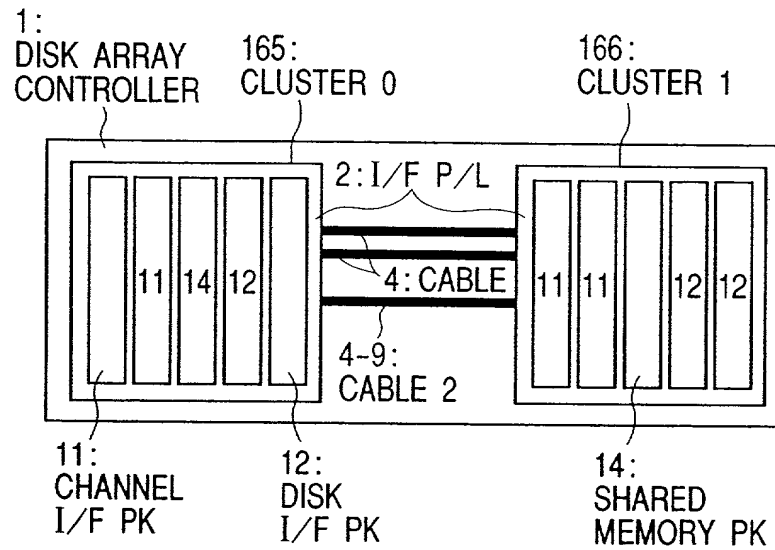


FIG. 34

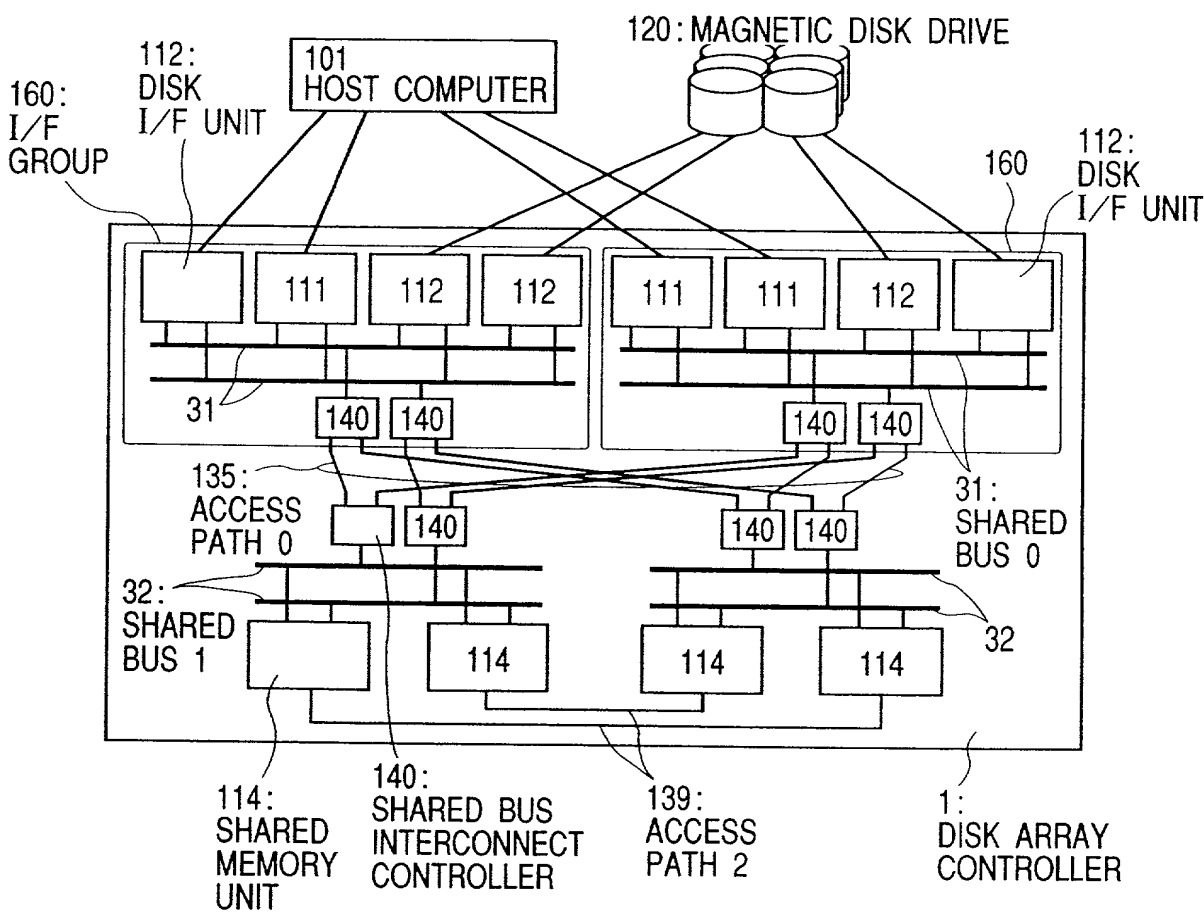


FIG. 35

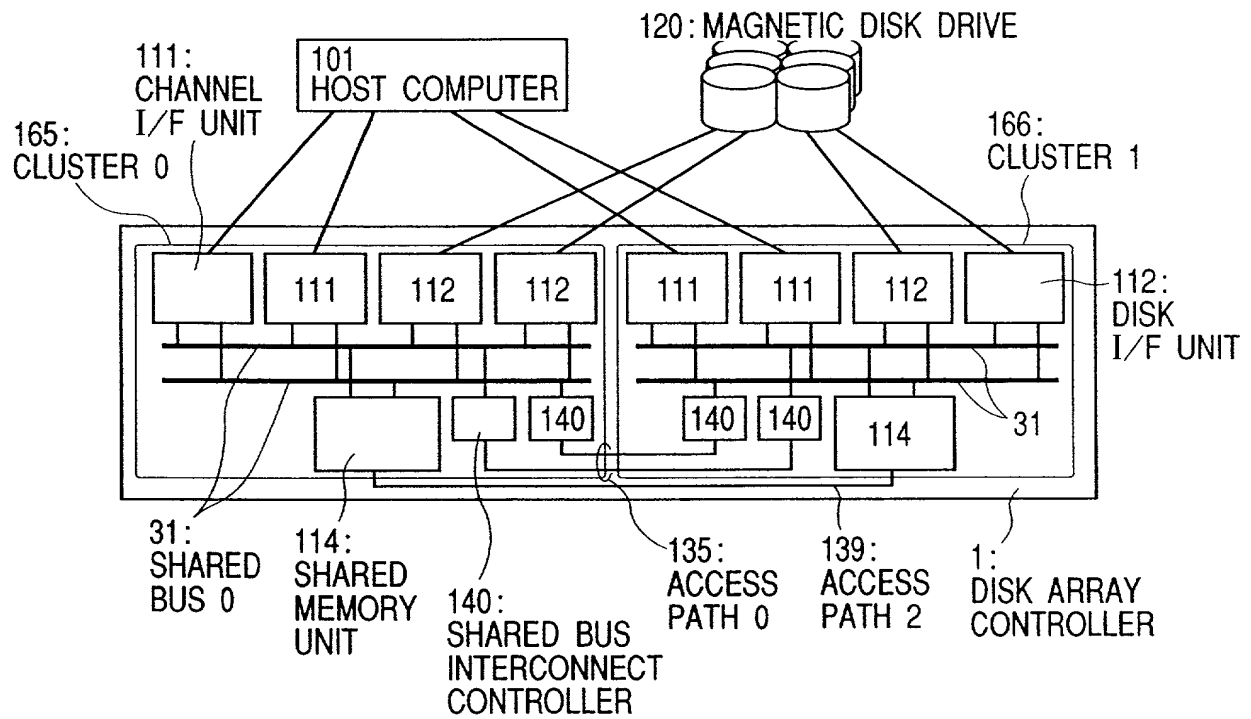


FIG. 36

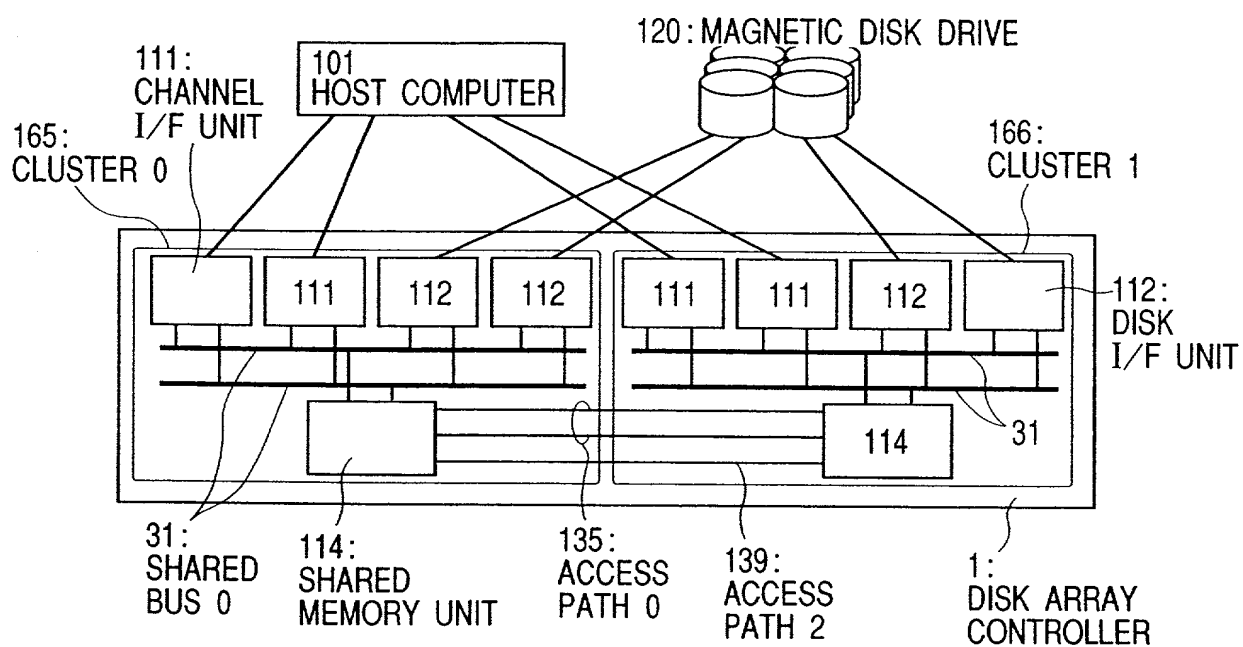


FIG. 37

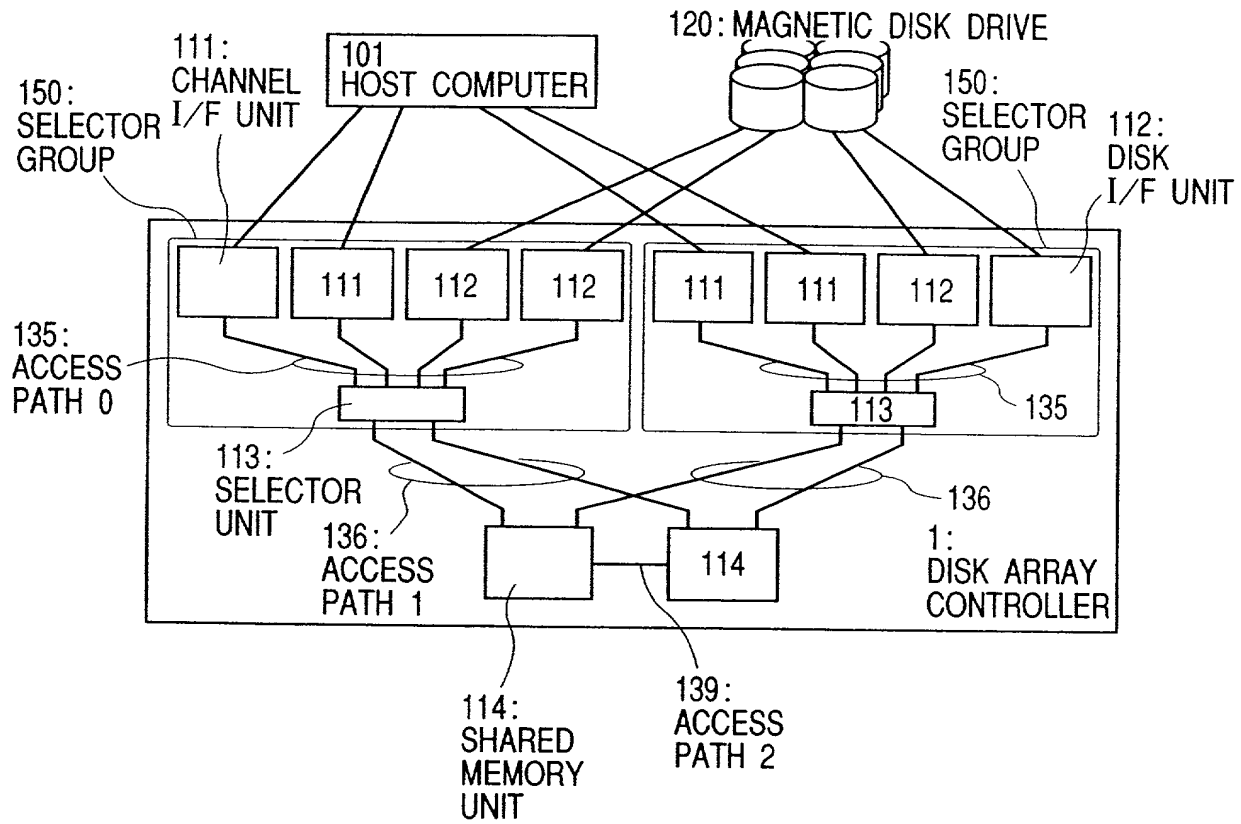


FIG. 38

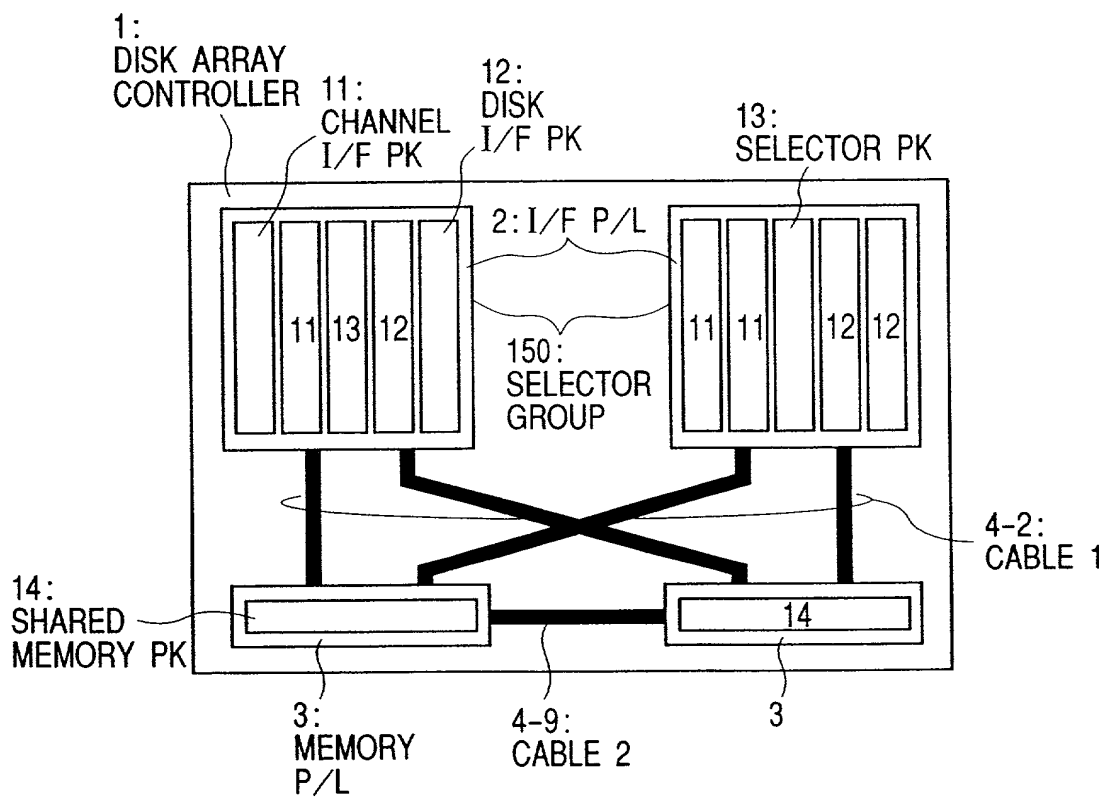


FIG. 39

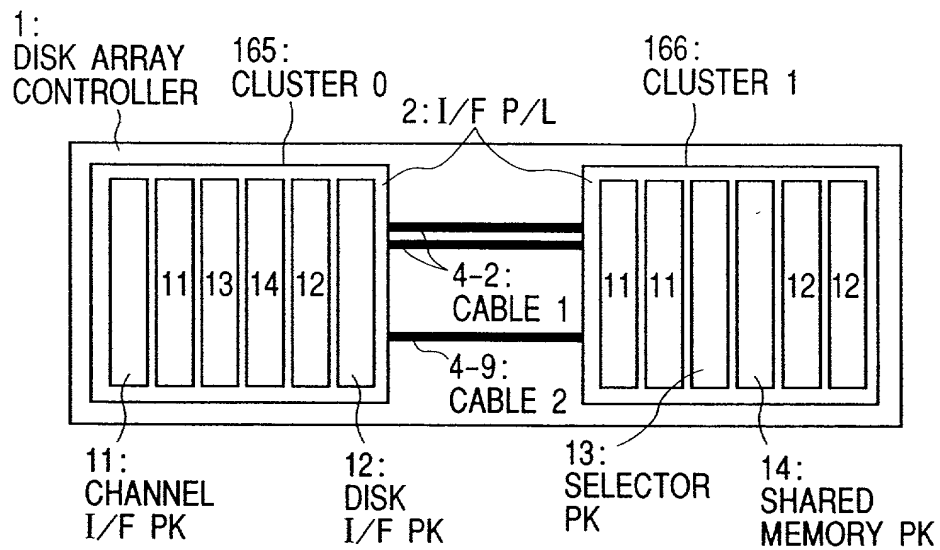


FIG. 40

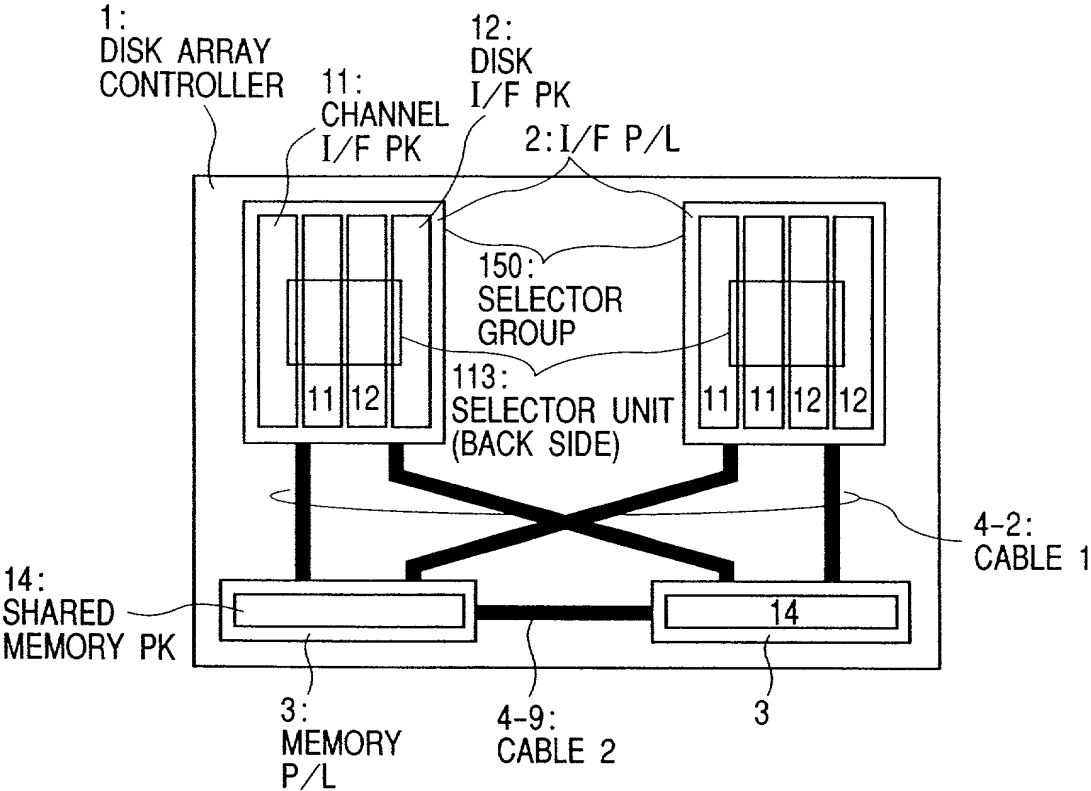


FIG. 41

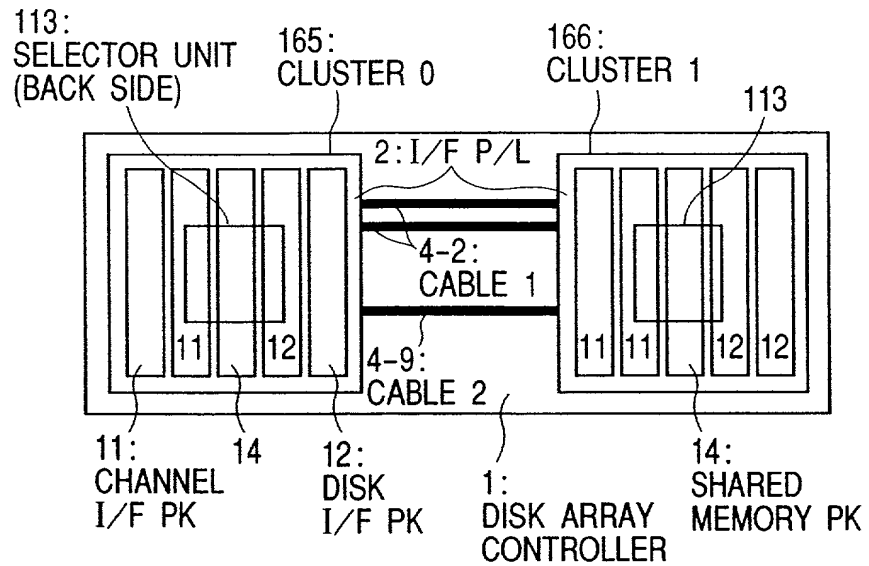
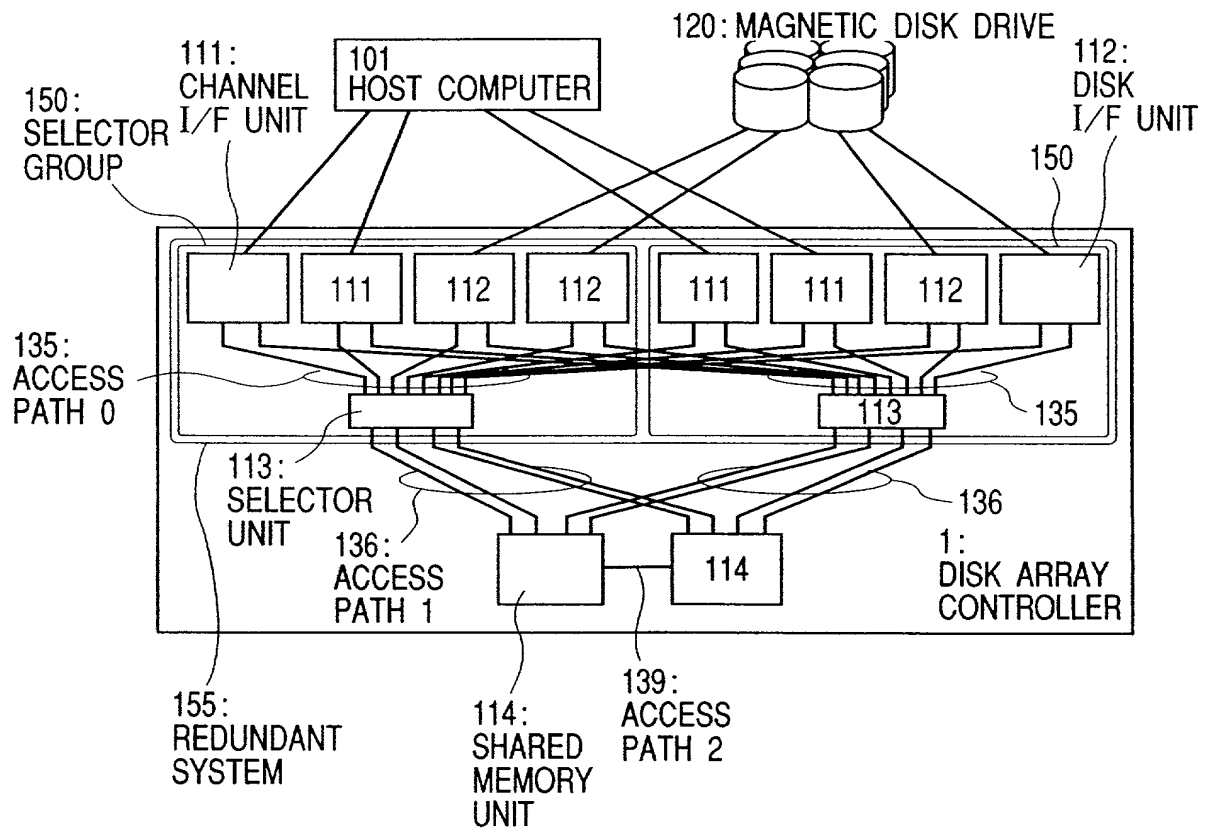


FIG. 42



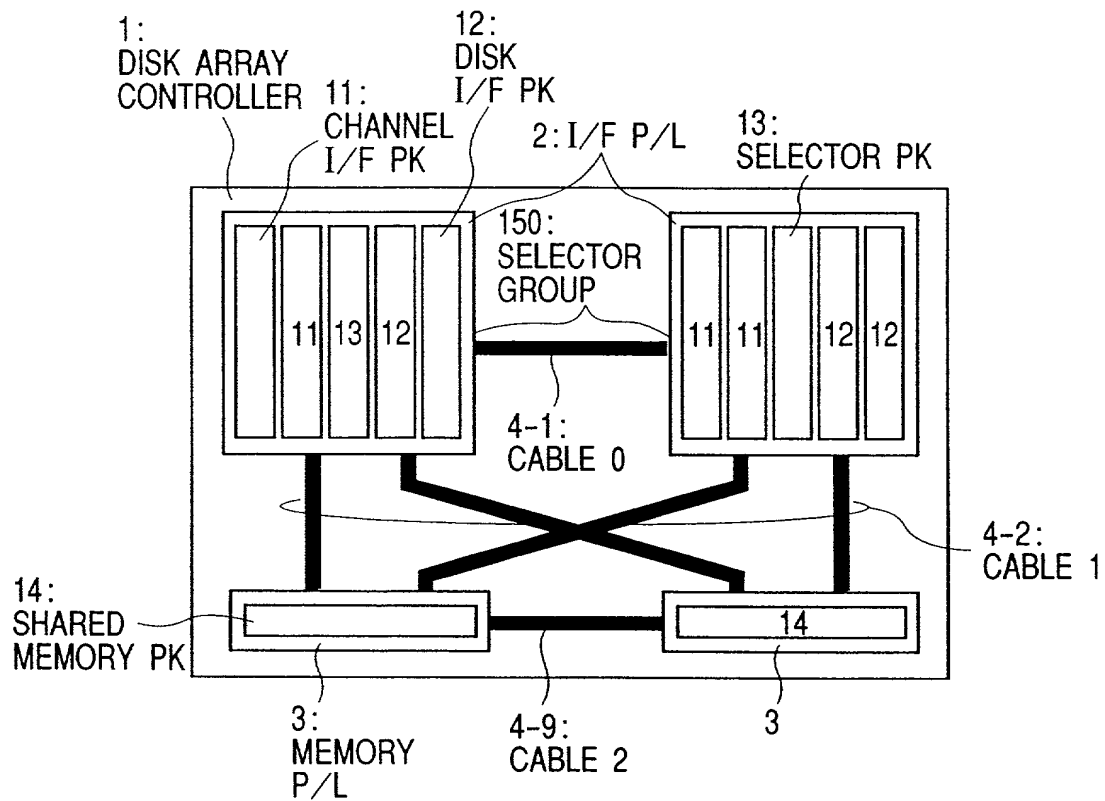


FIG. 44

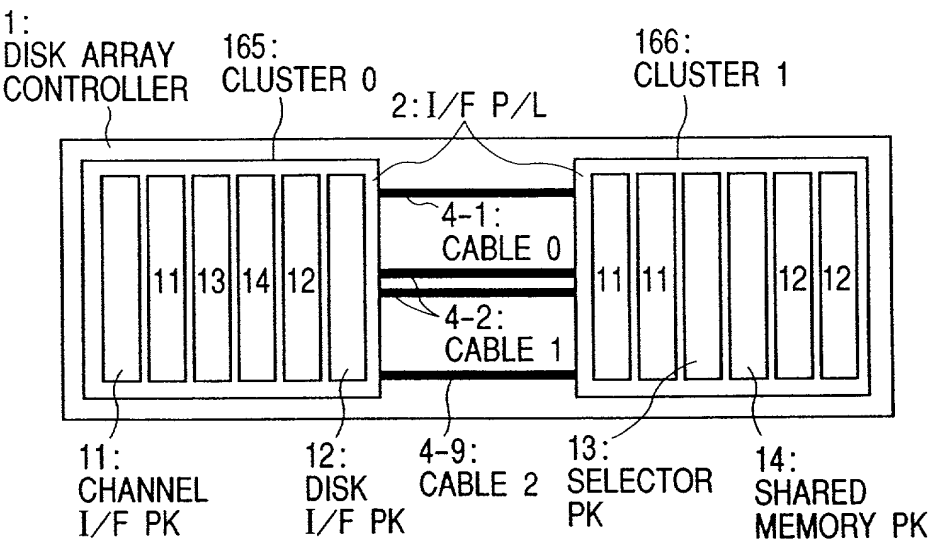


FIG. 45

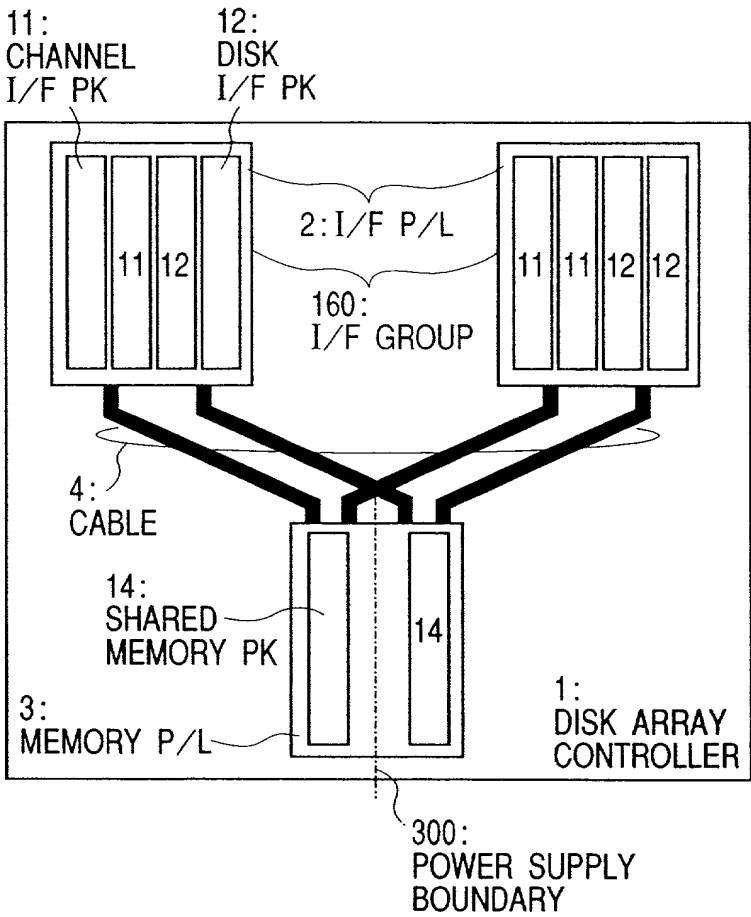


FIG. 46

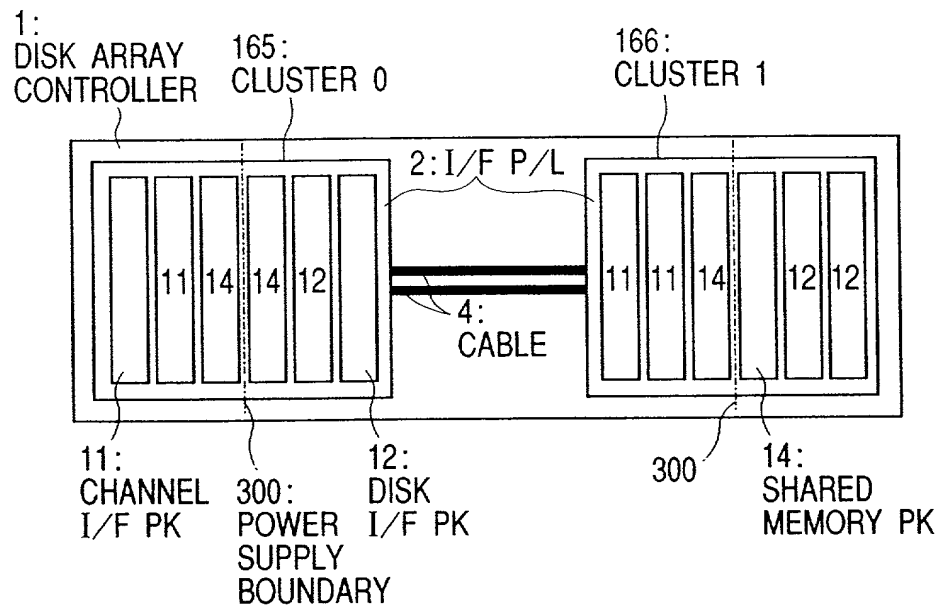


FIG. 47

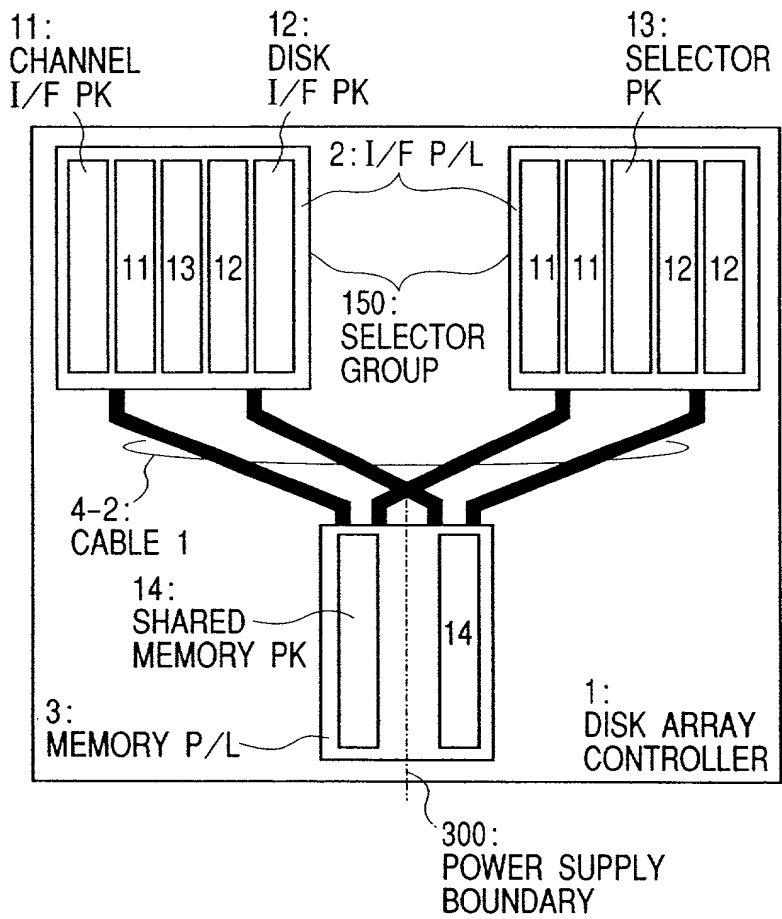
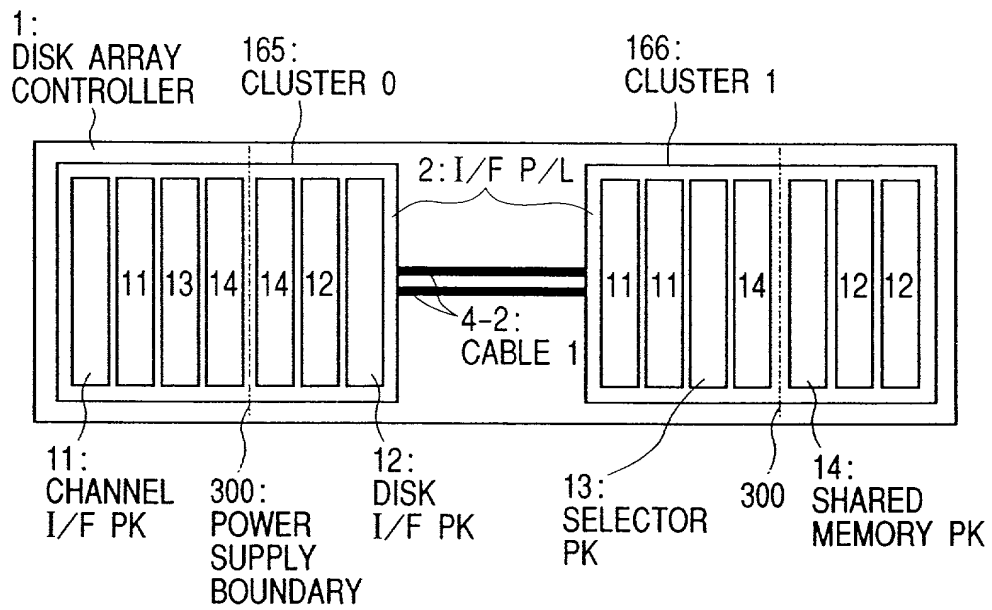


FIG. 48



49/83

FIG. 49

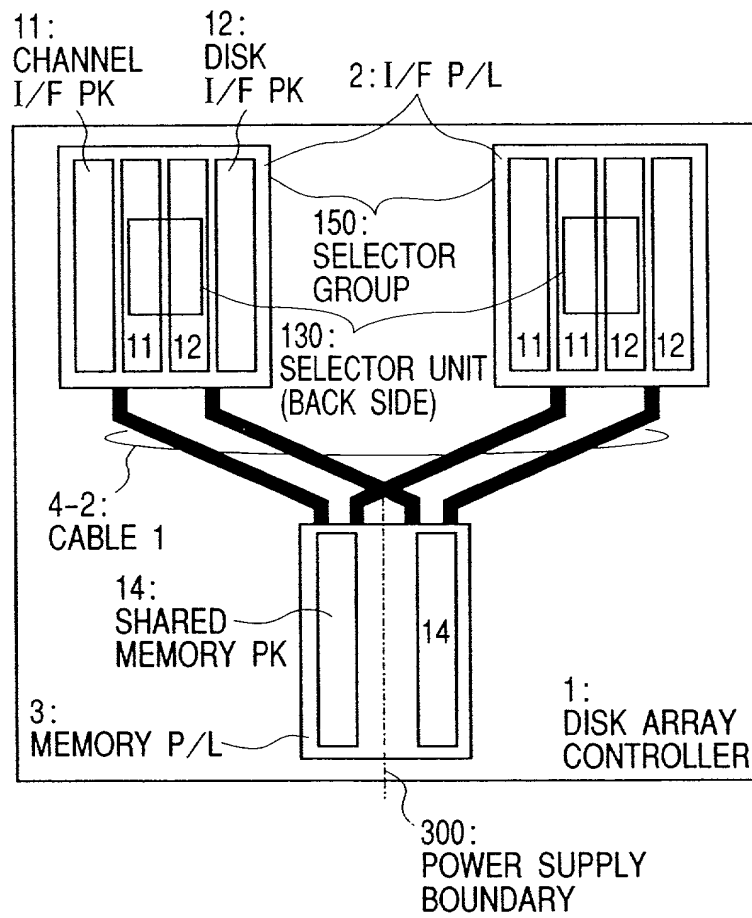


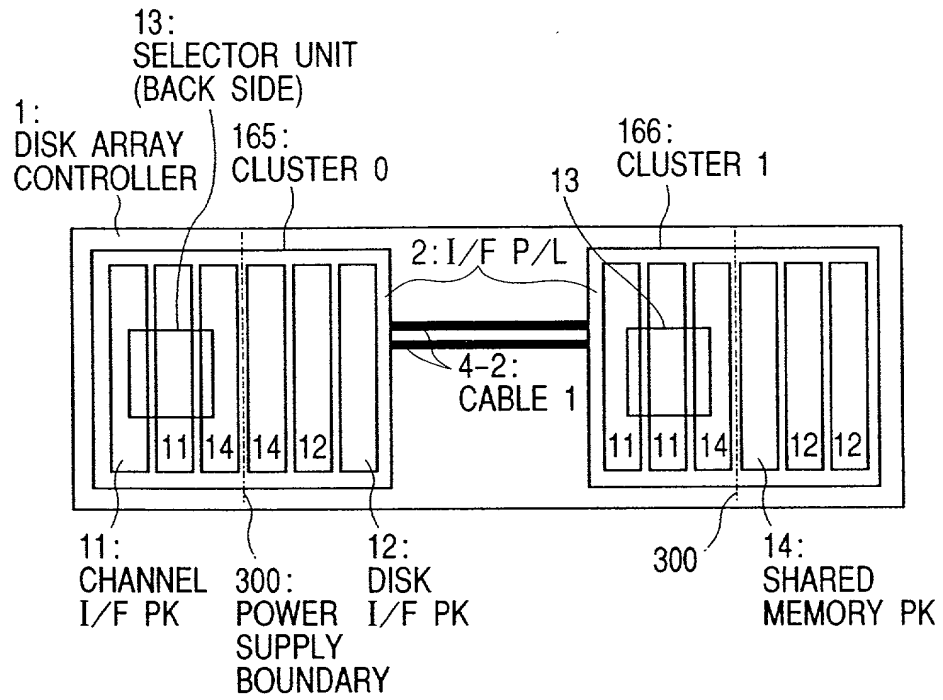
FIG. 50

FIG. 51

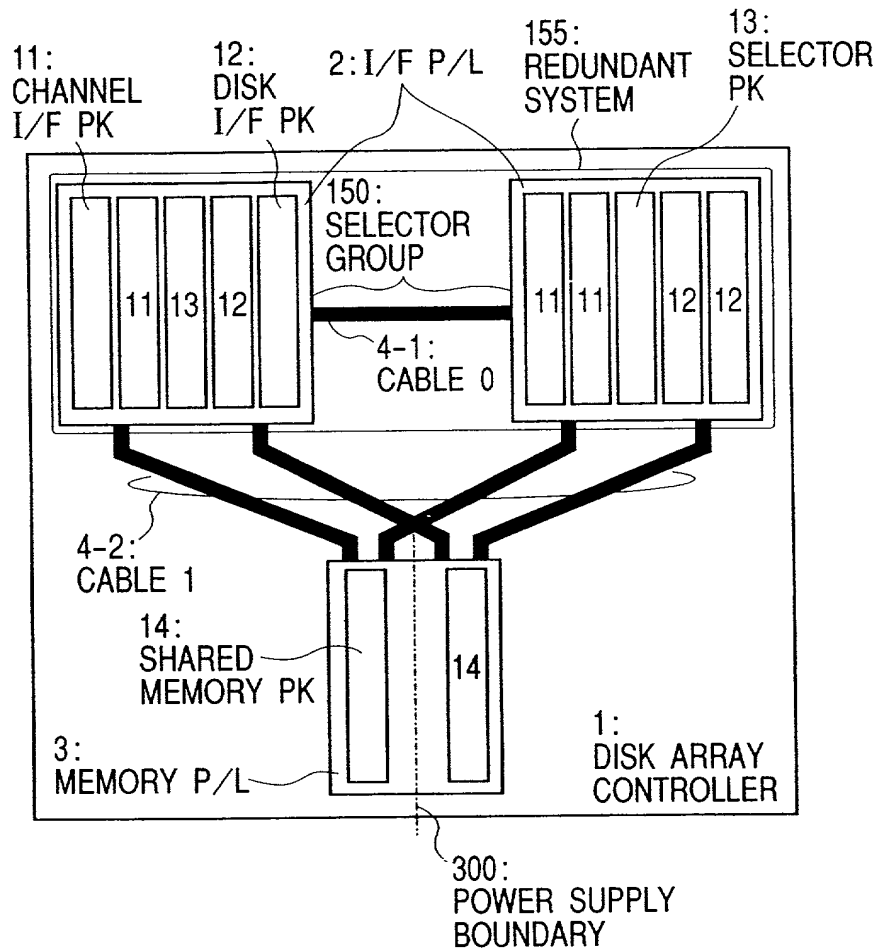


FIG. 52

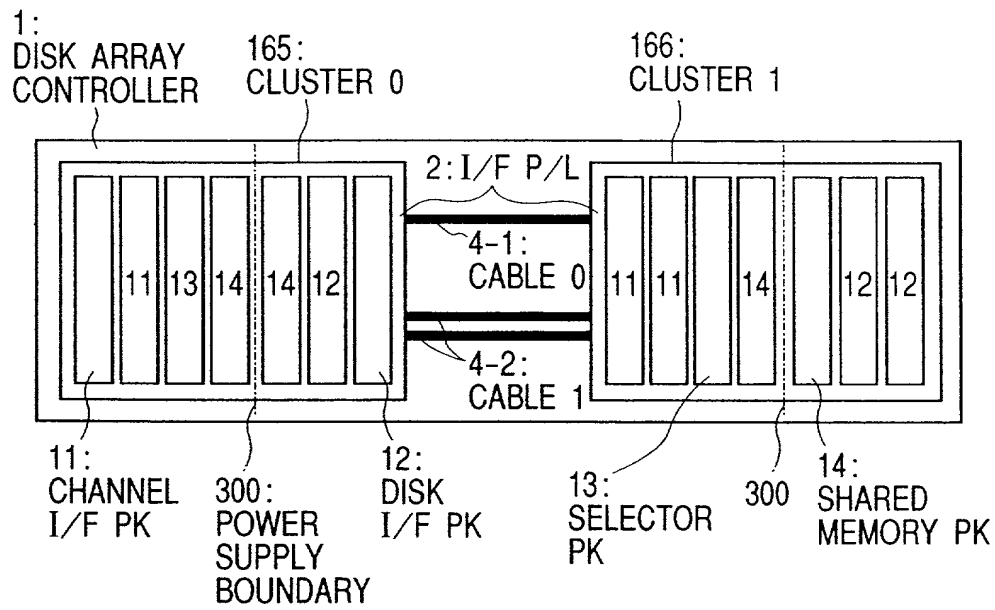


FIG. 53

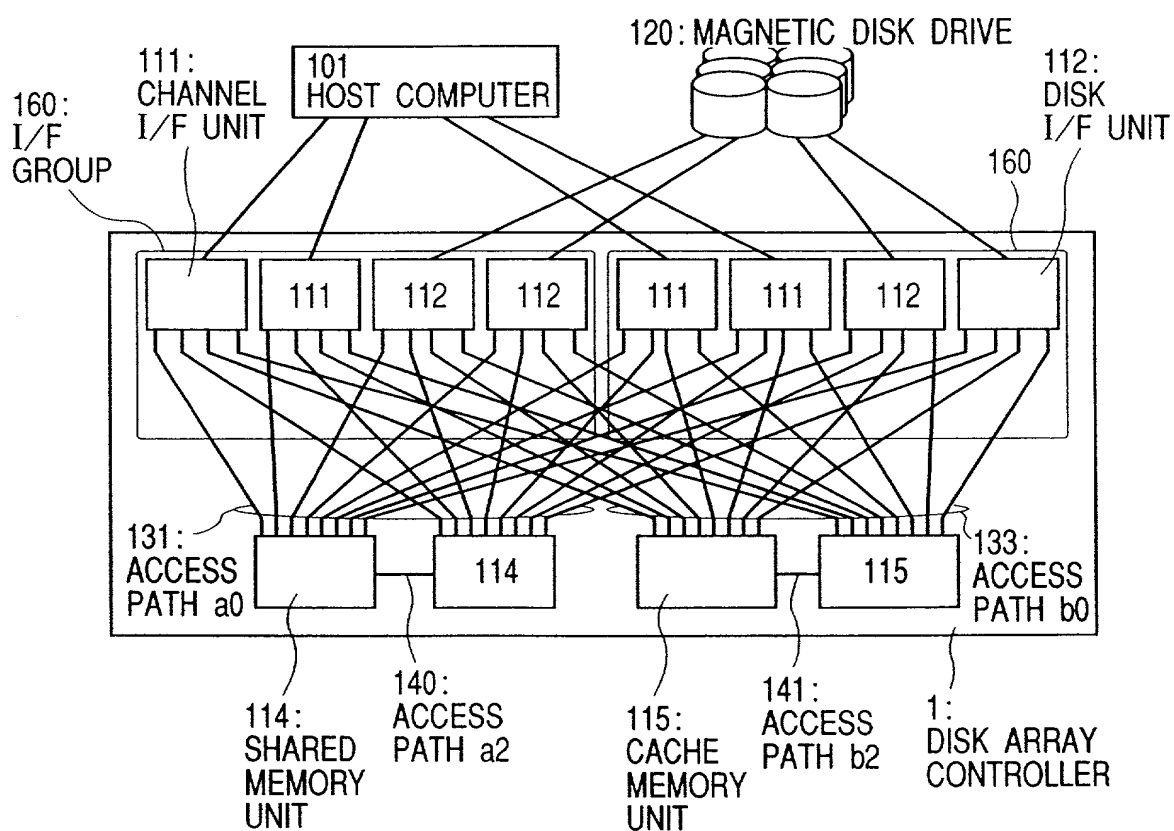


FIG. 54

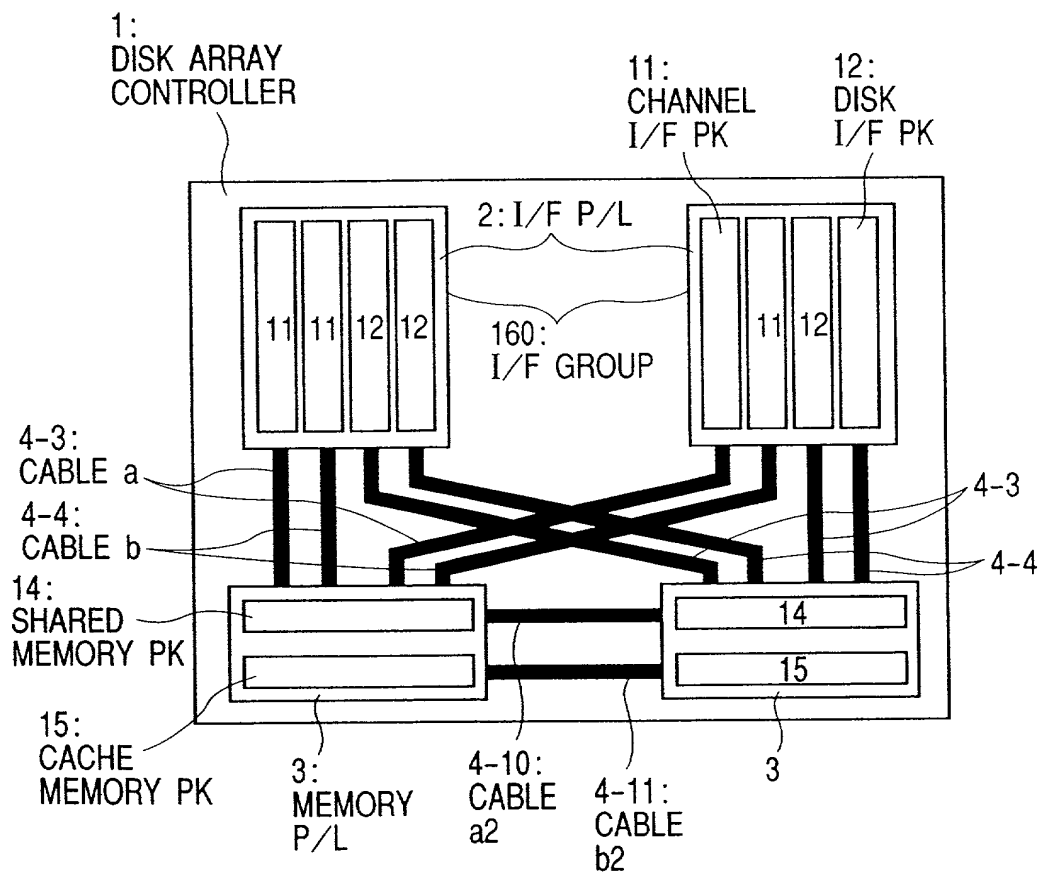


FIG. 55

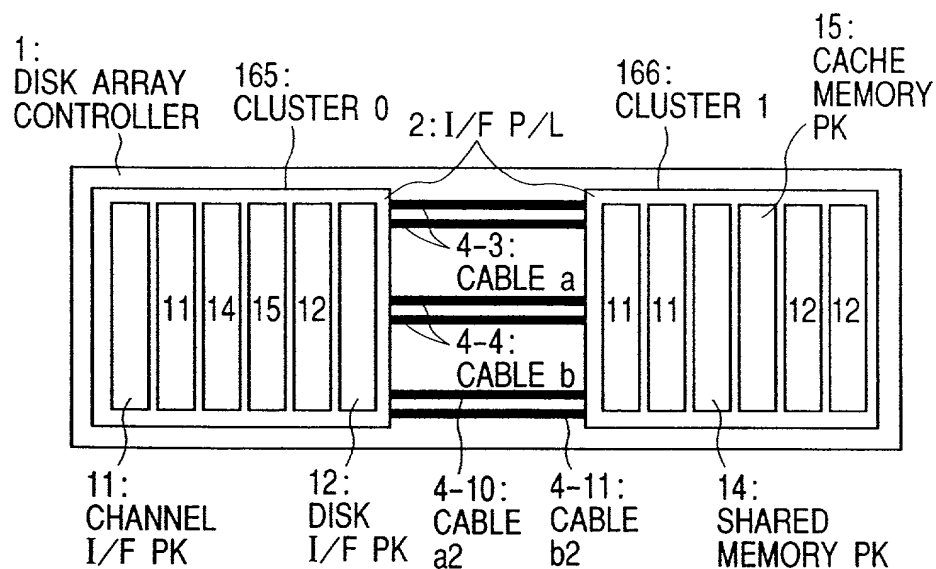


FIG. 56

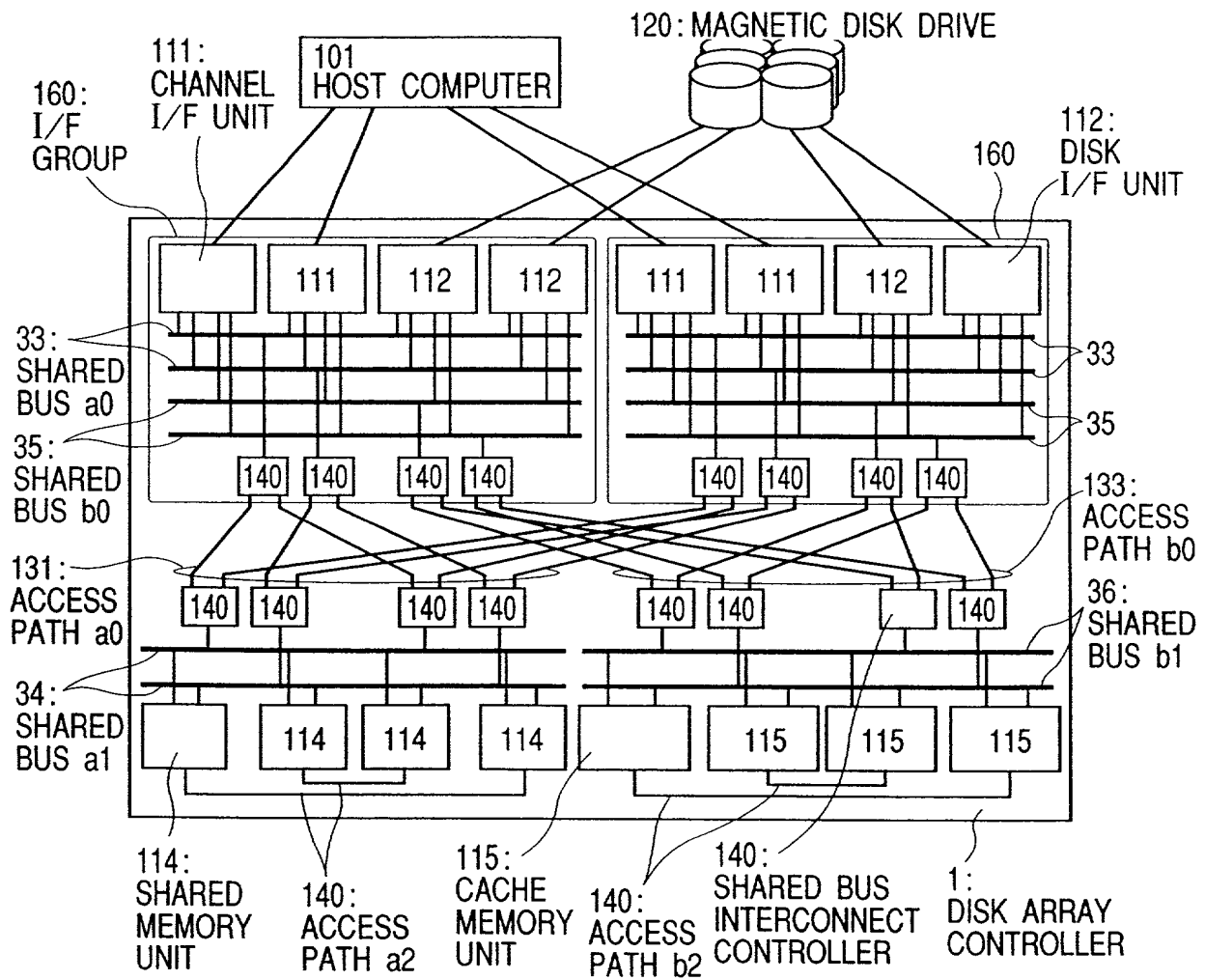


FIG. 57

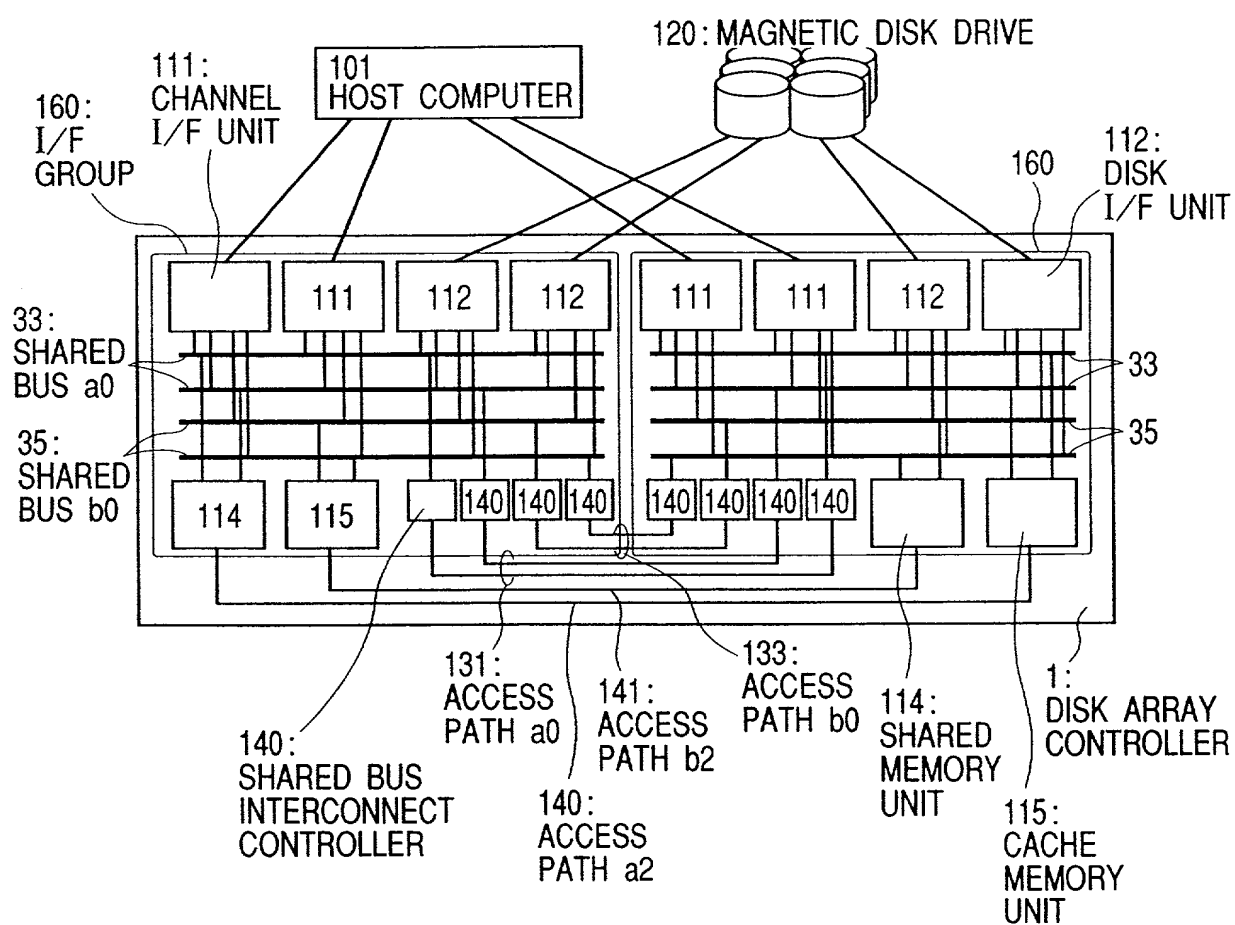


FIG. 58

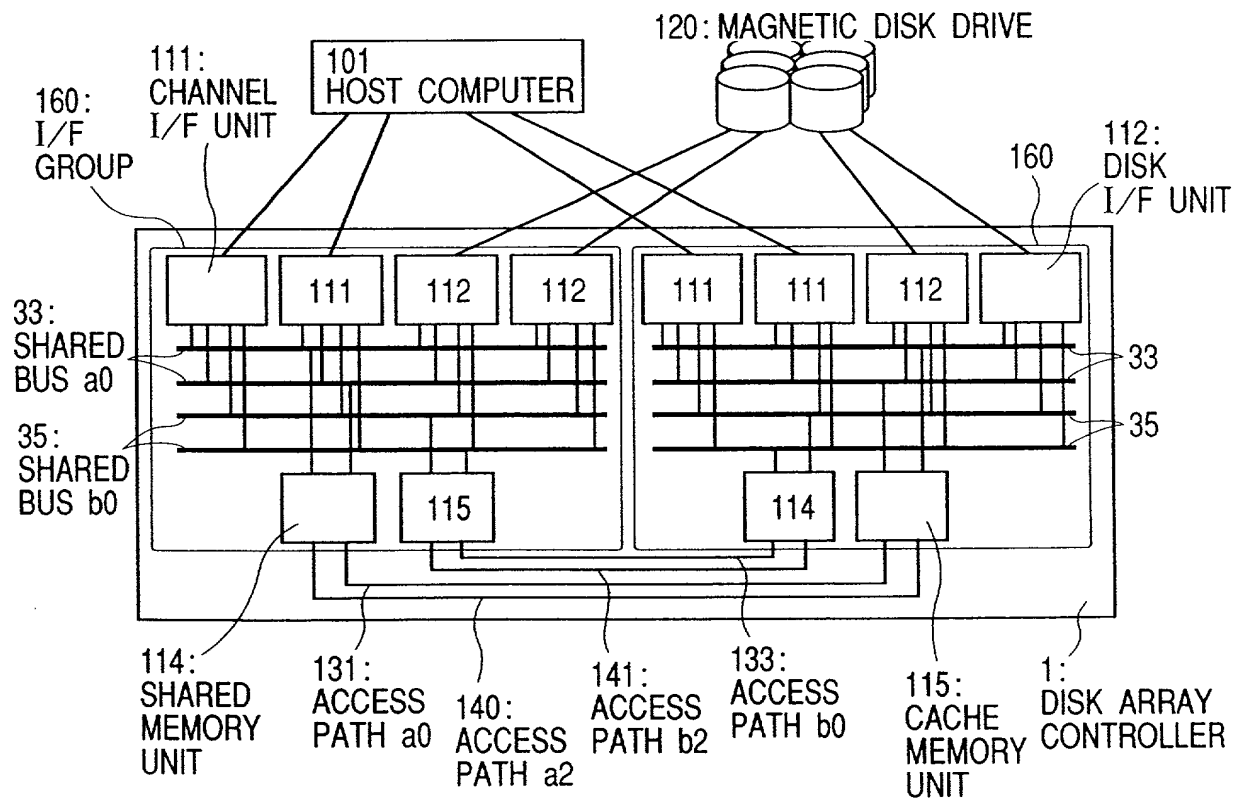
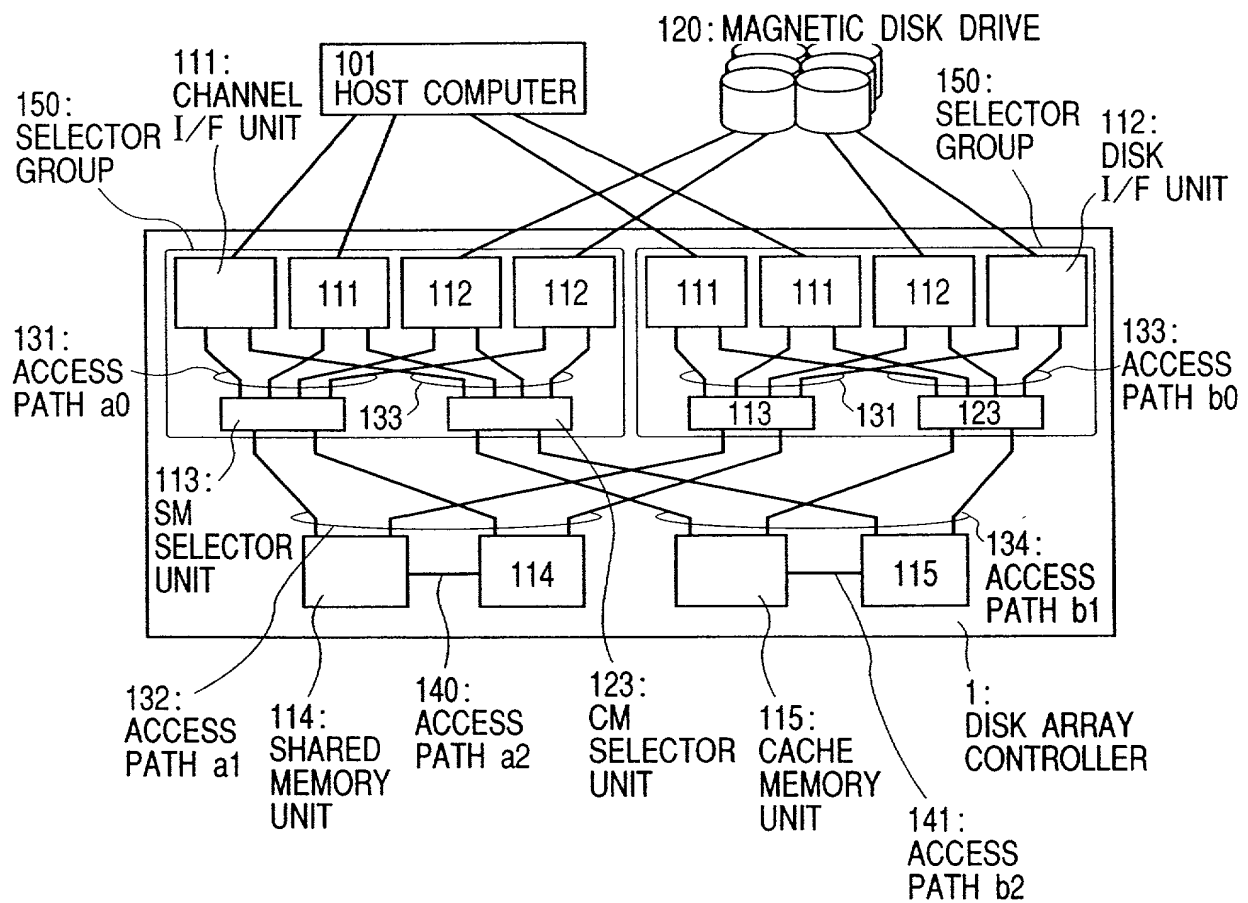
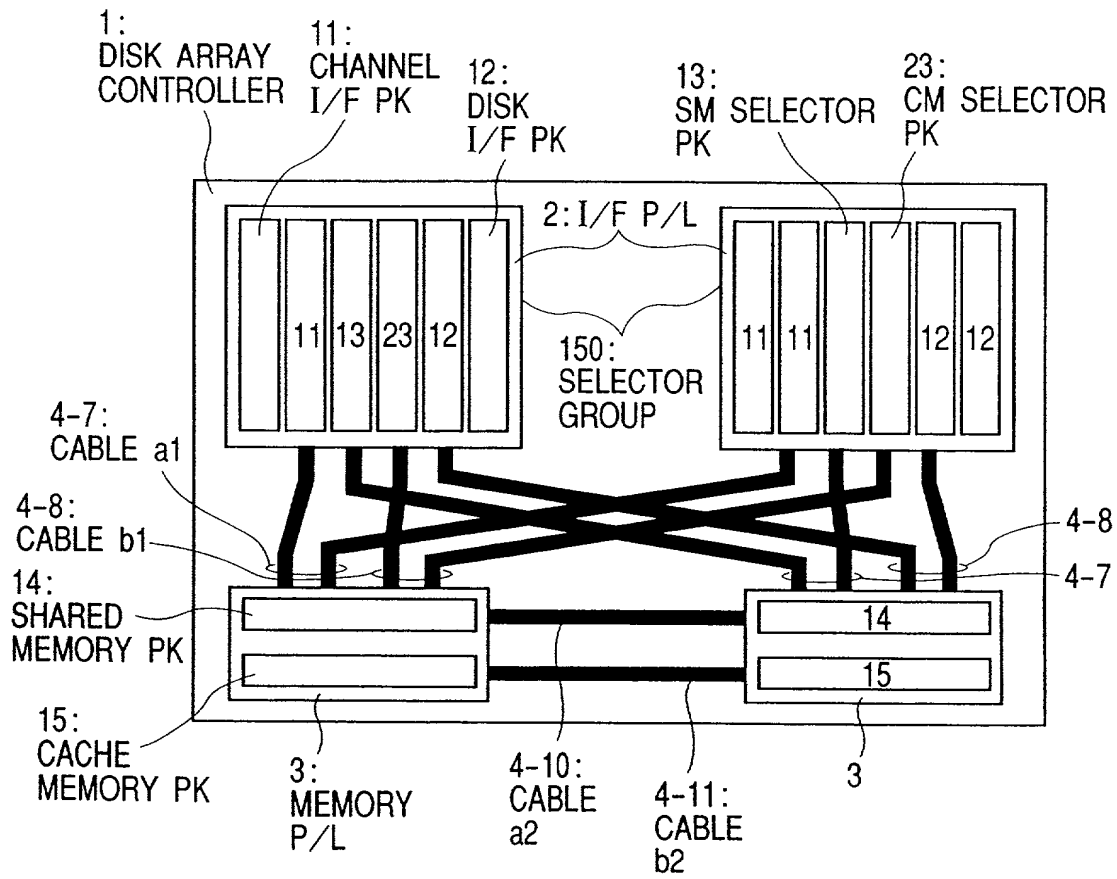


FIG. 59



60/83

FIG. 60



61/83

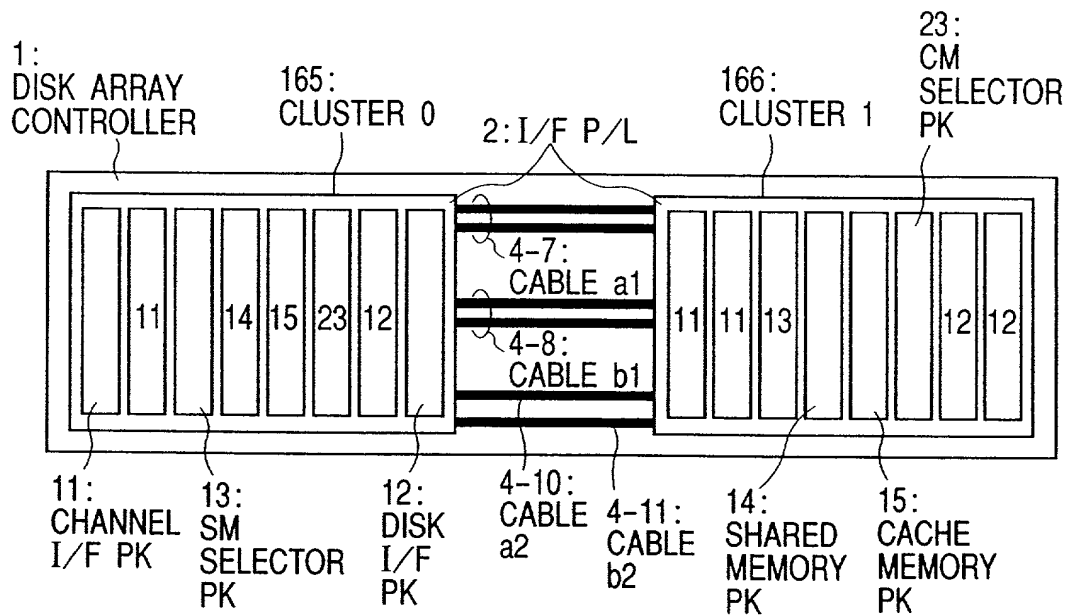
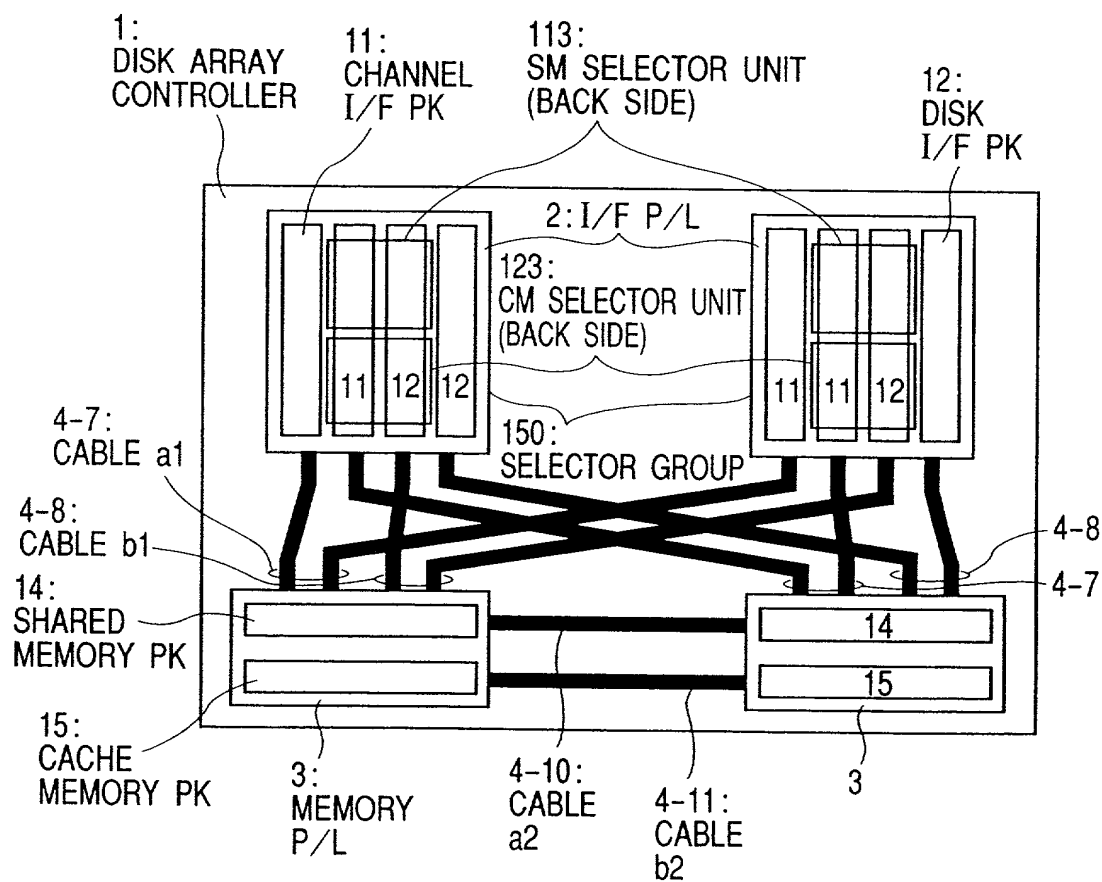
FIG. 61

FIG. 62



63/83

FIG. 63

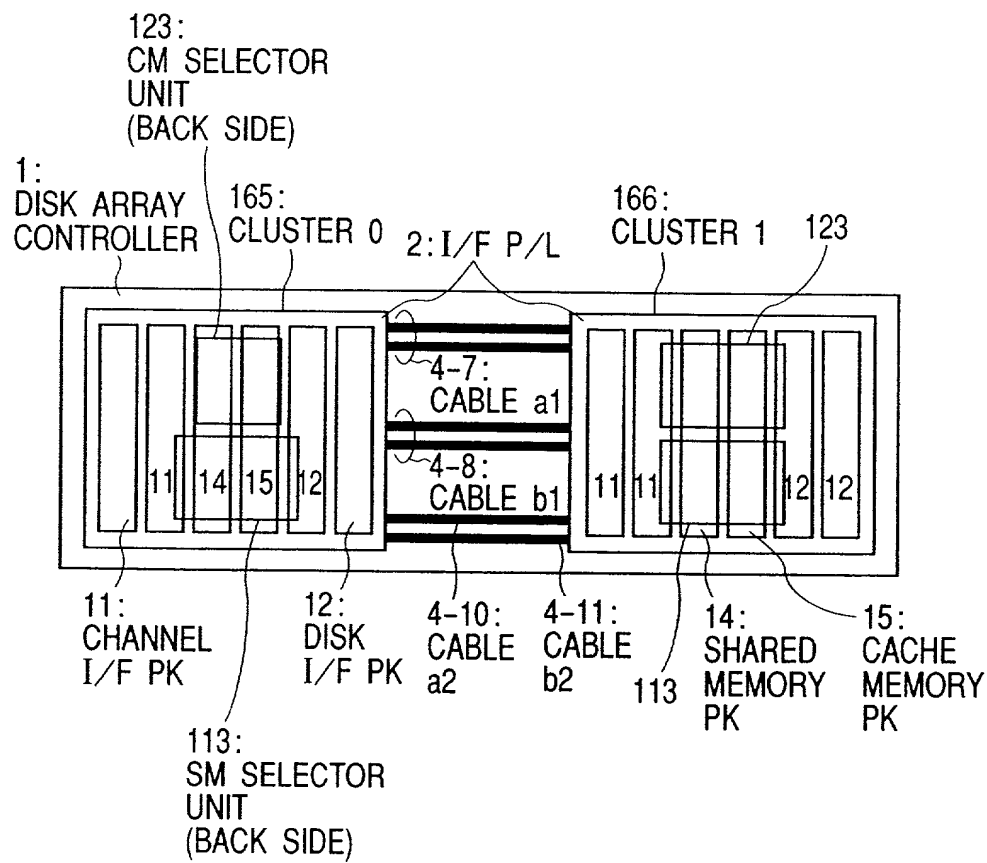


FIG. 64

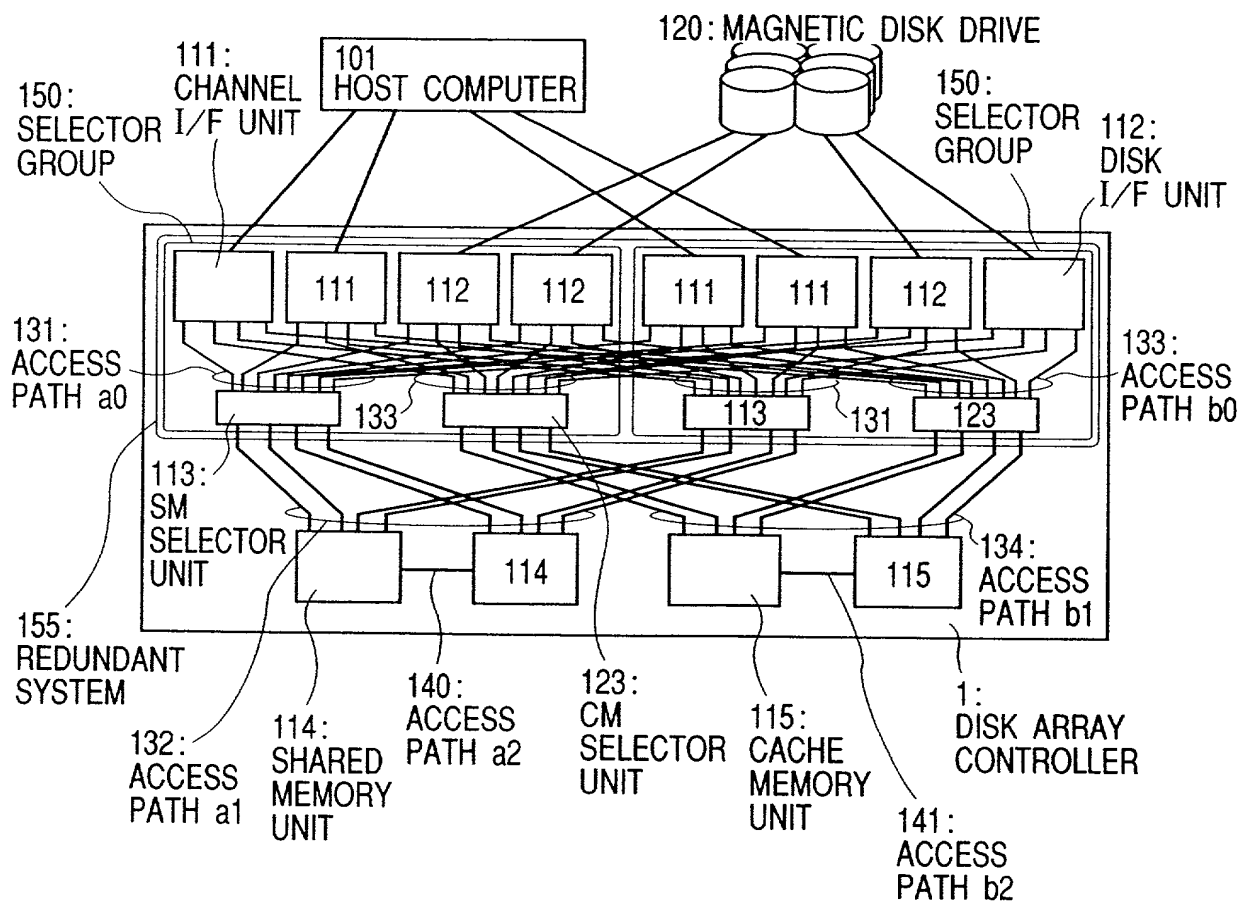
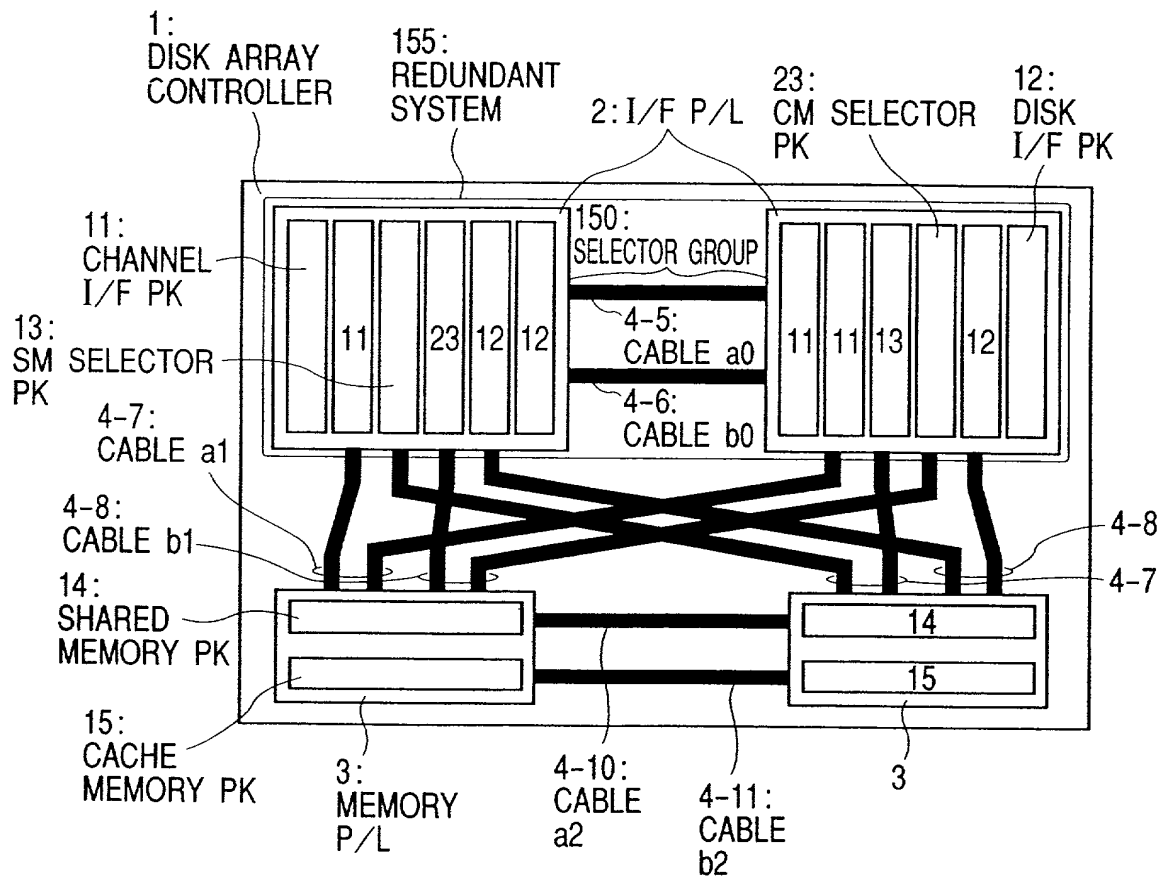
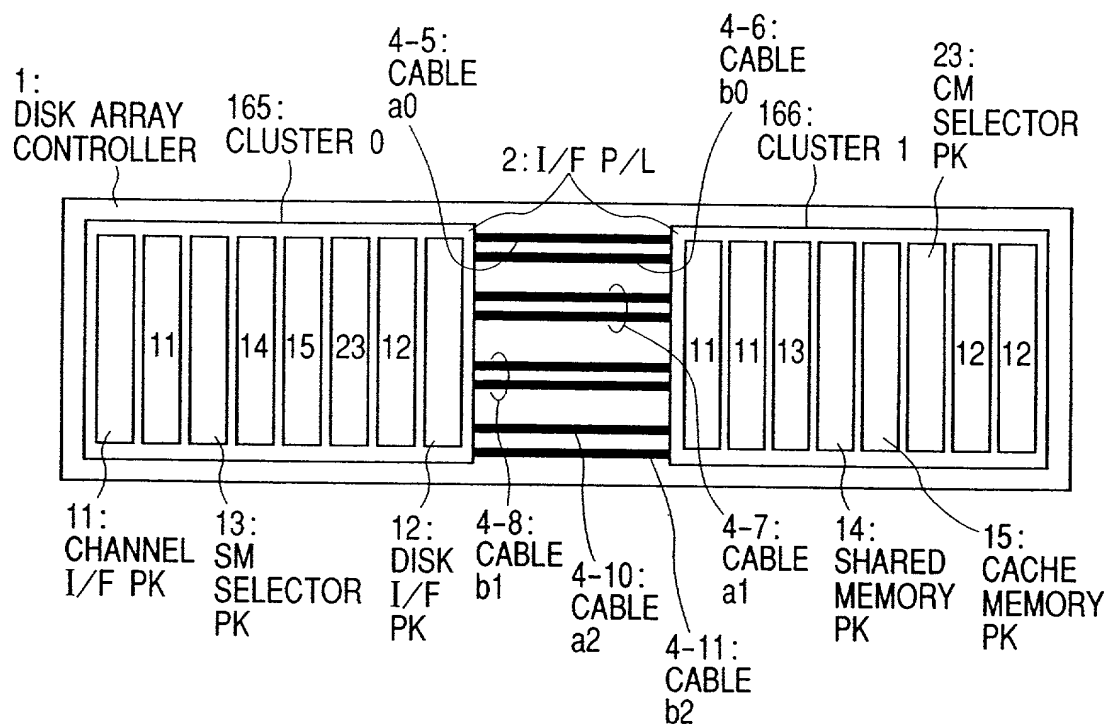


FIG. 65



66/83

FIG. 66



67/83

FIG. 67

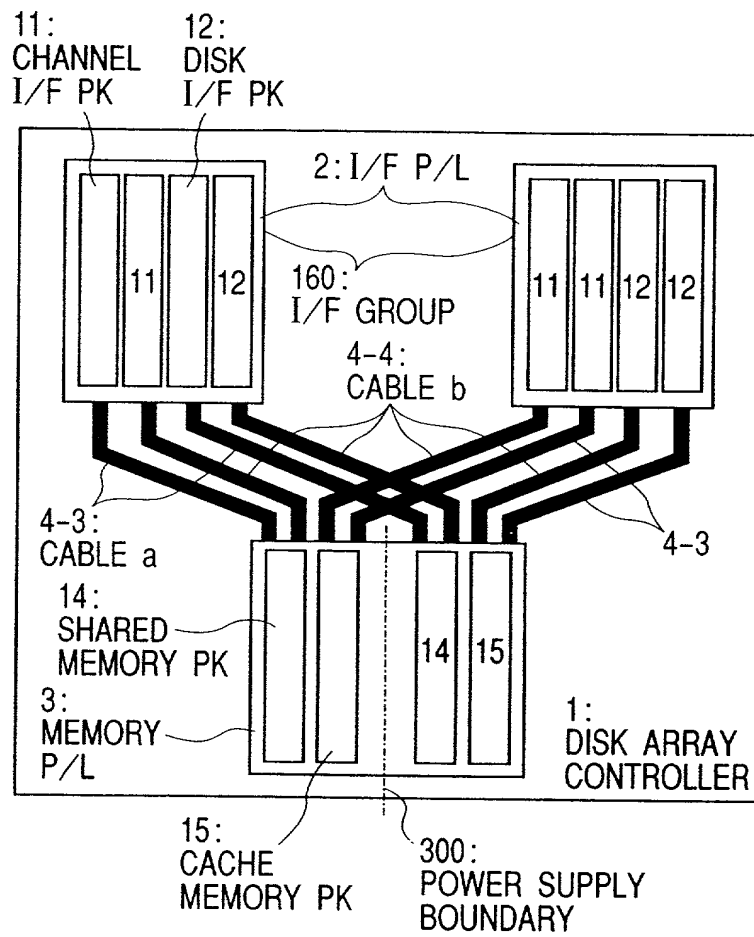
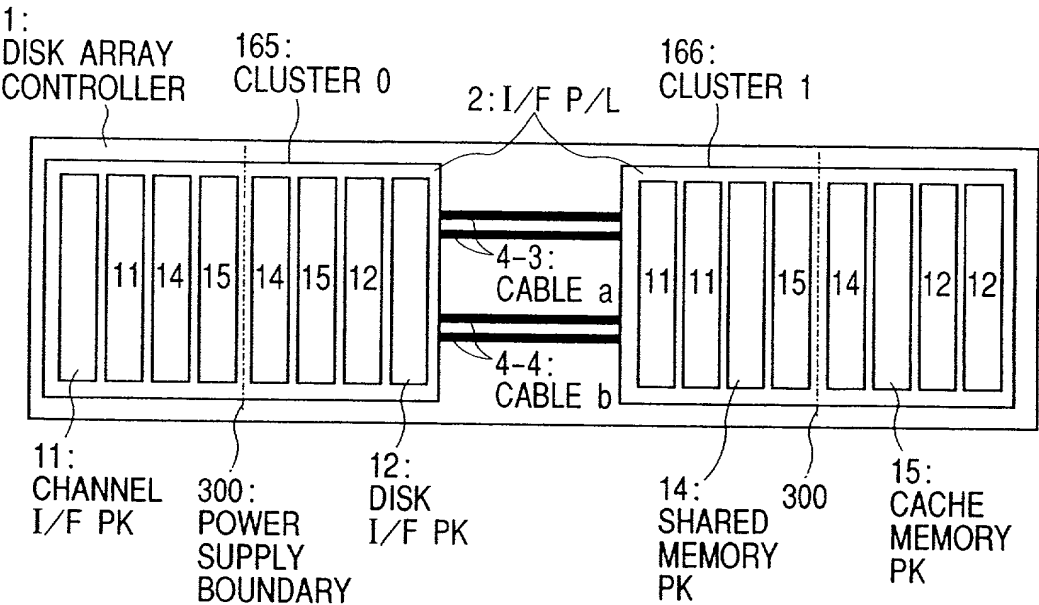
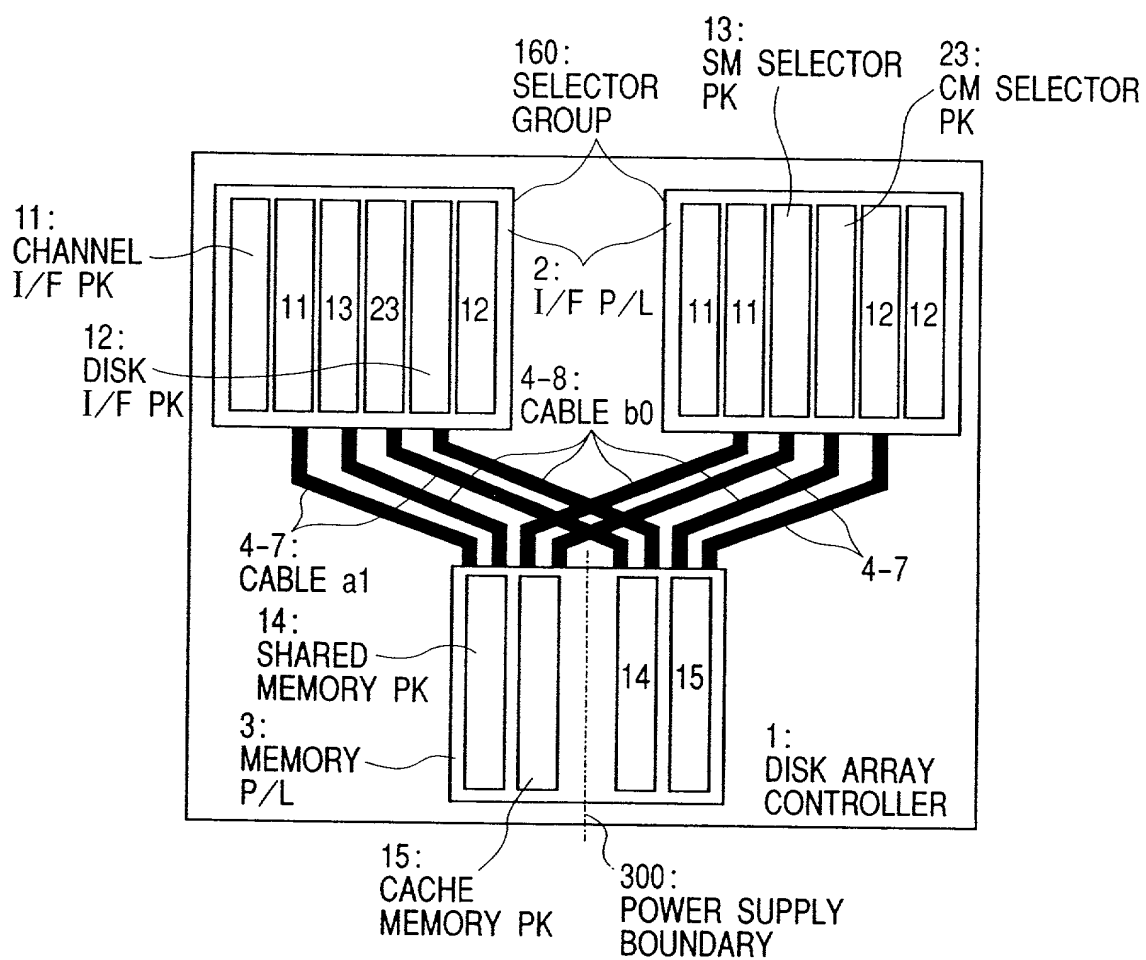


FIG. 68



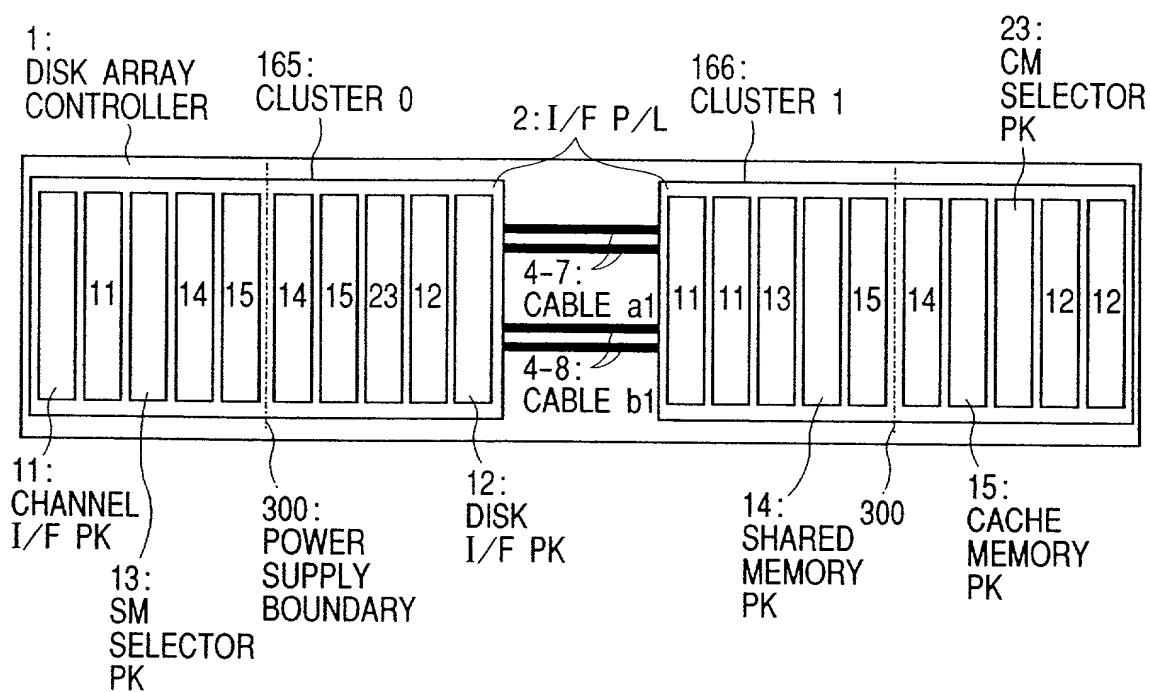
69/83

FIG. 69



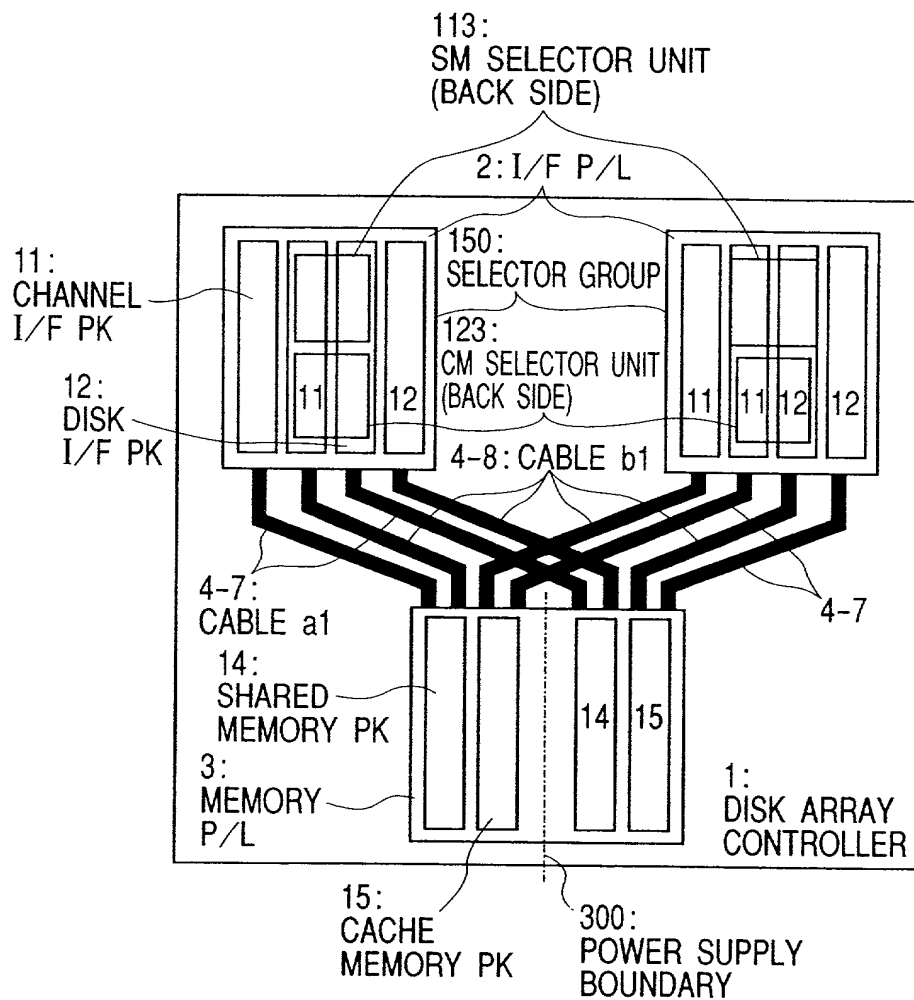
70/83

FIG. 70



71 / 83

FIG. 71



72/83

FIG. 72

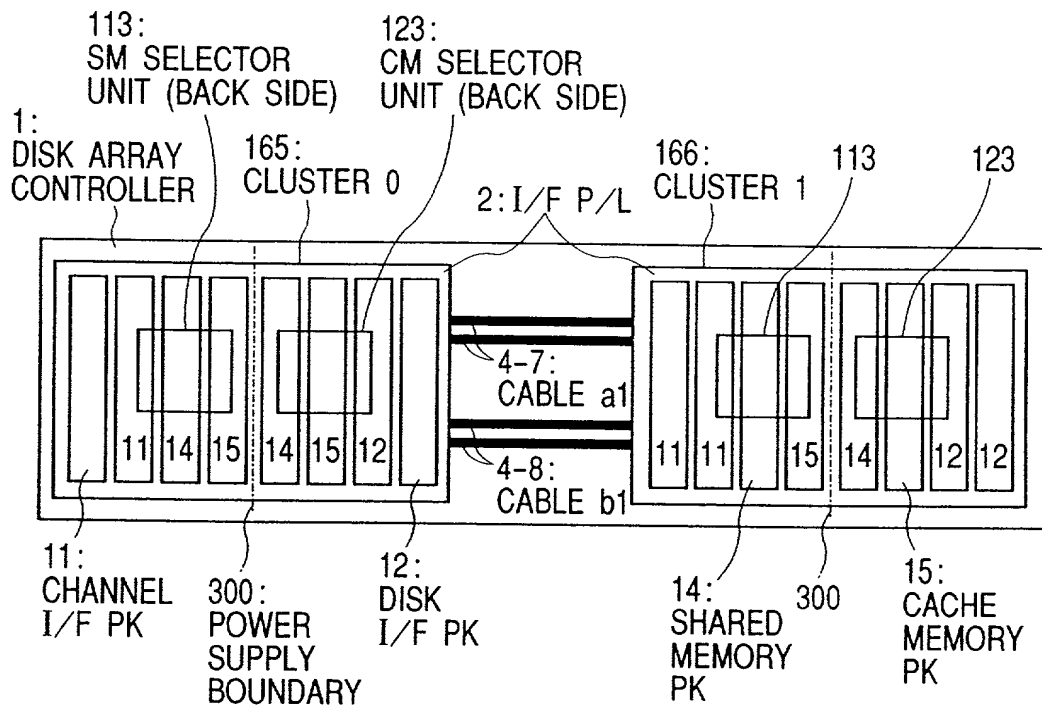
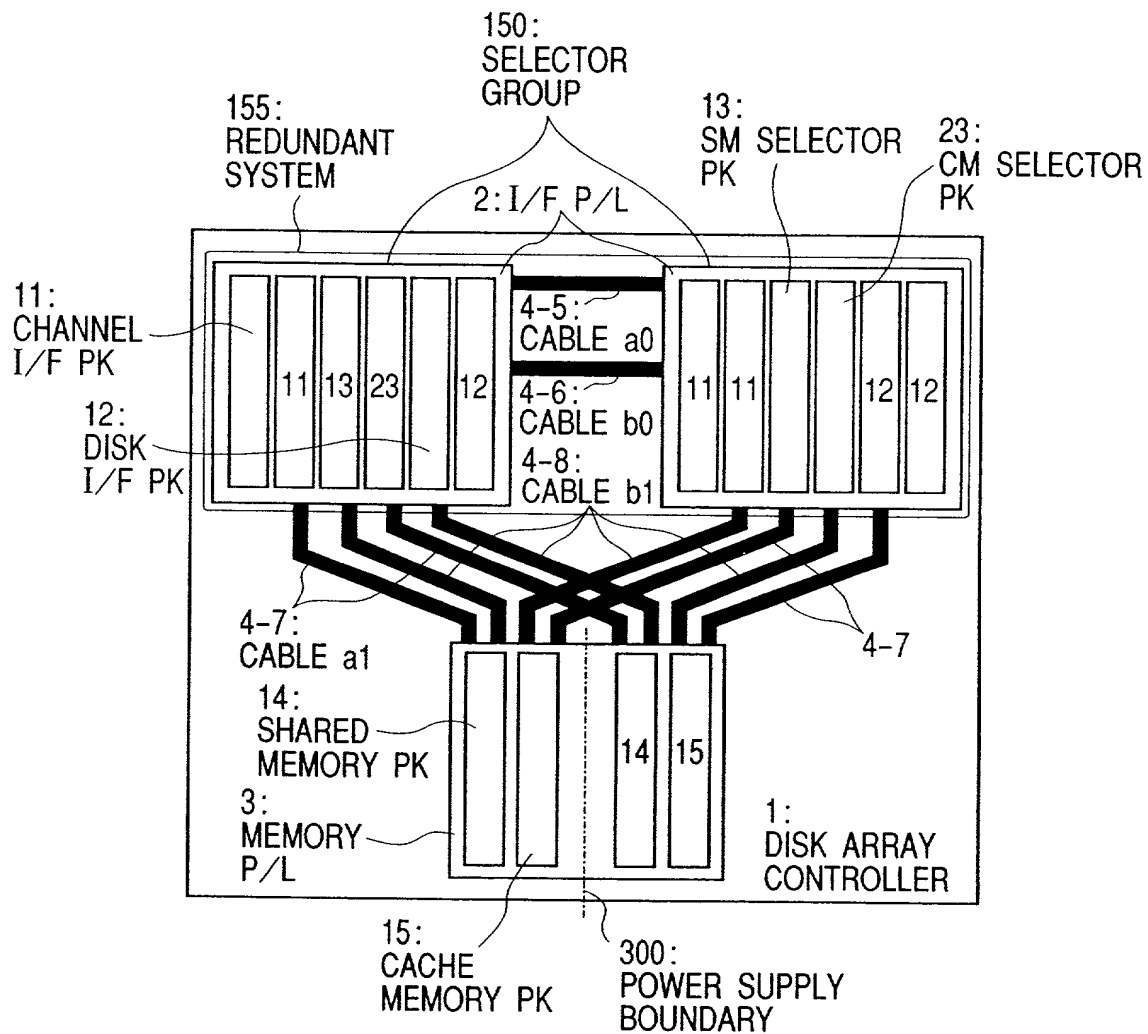
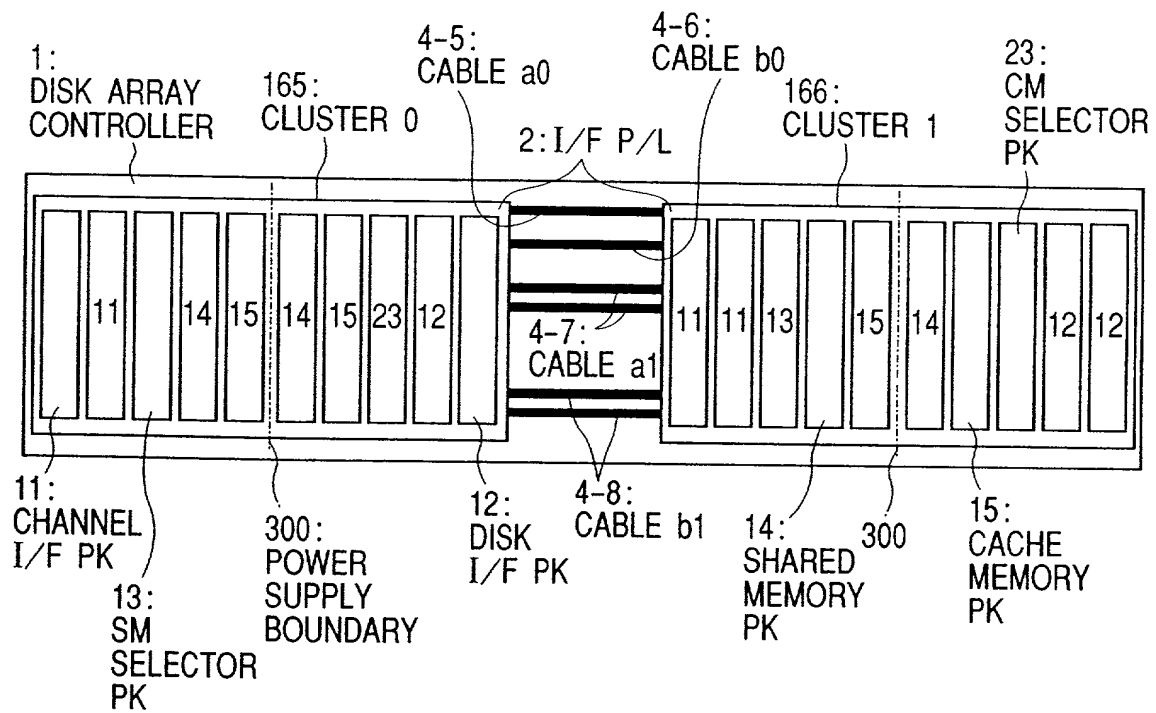


FIG. 73



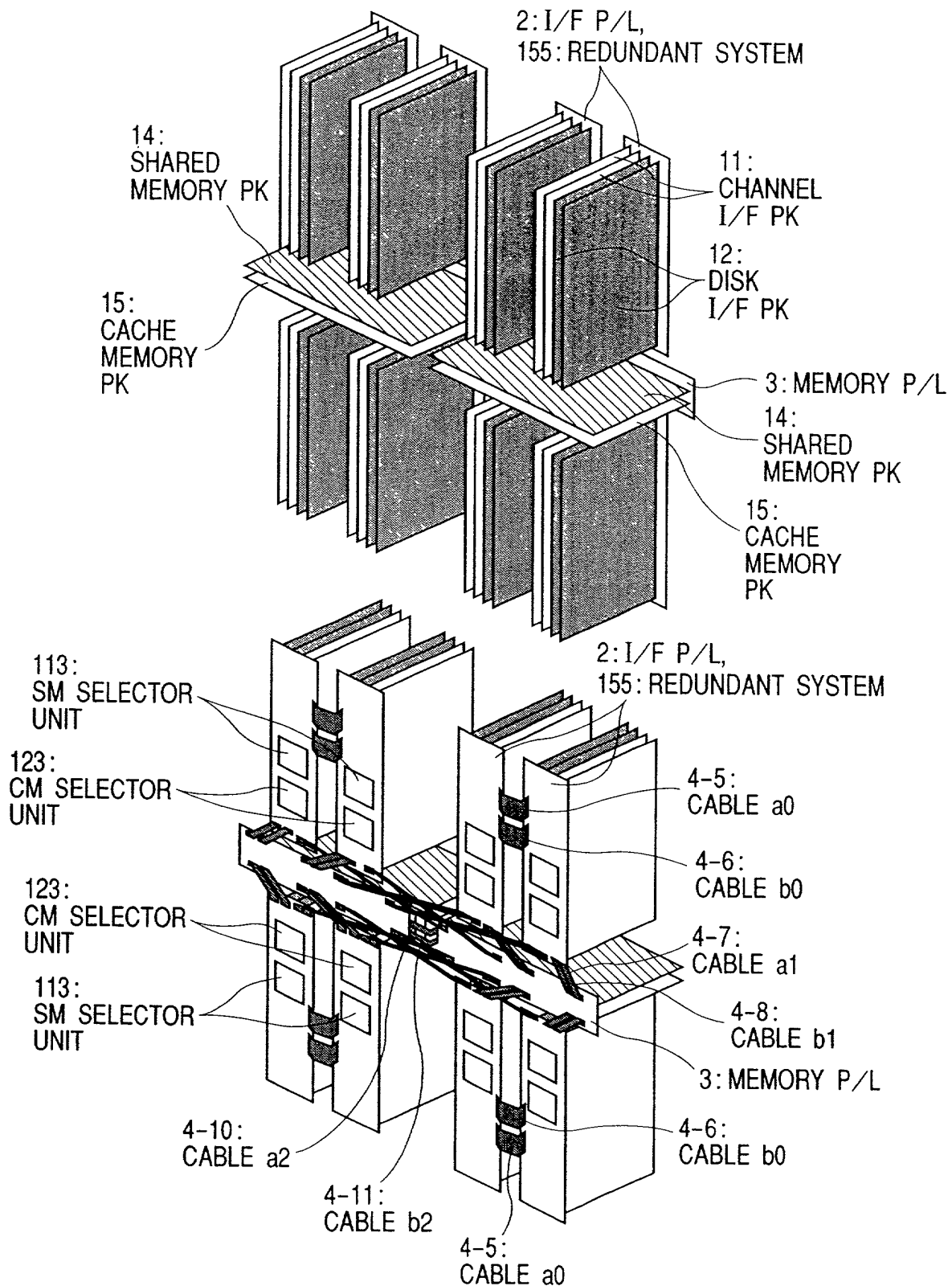
74/83

FIG. 74



75/83

FIG. 75



76/83

FIG. 76

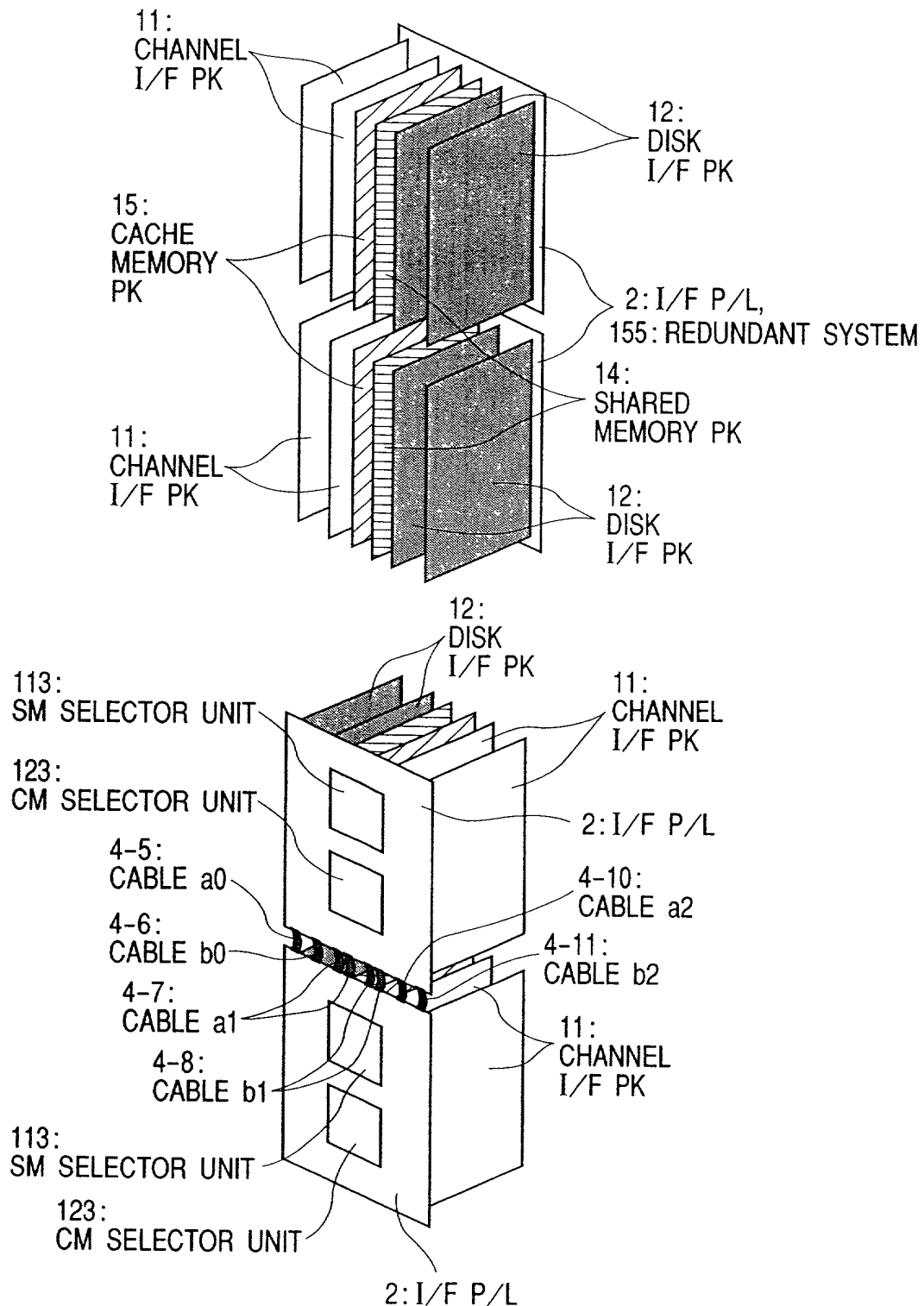
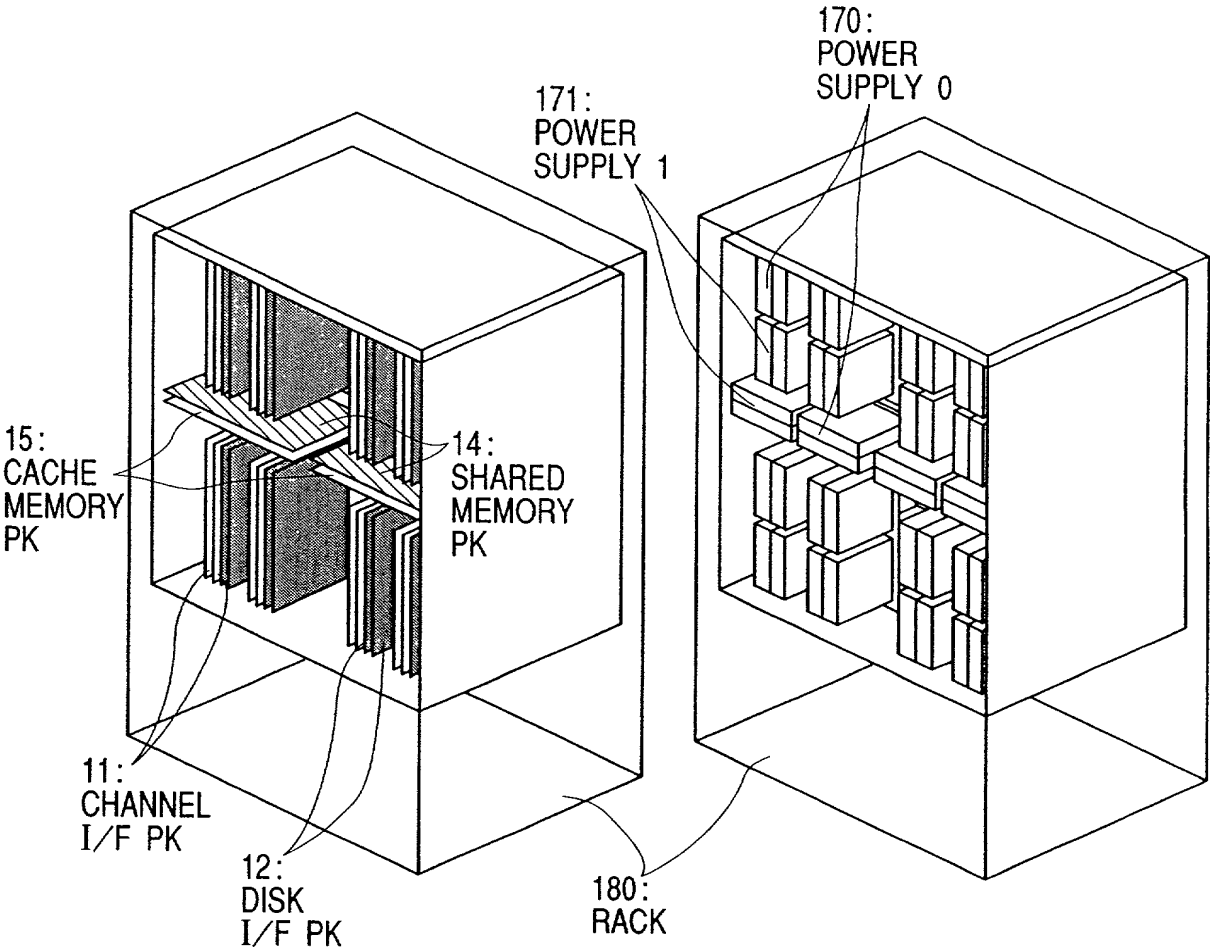
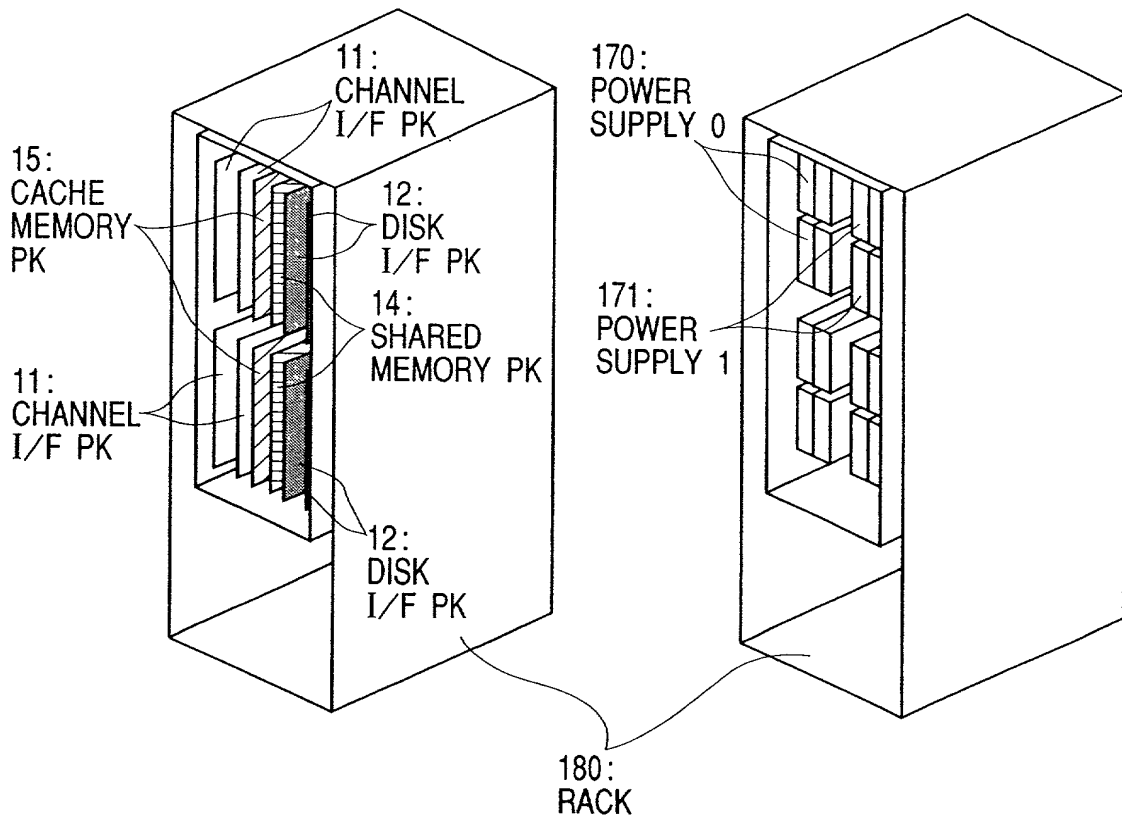


FIG. 77



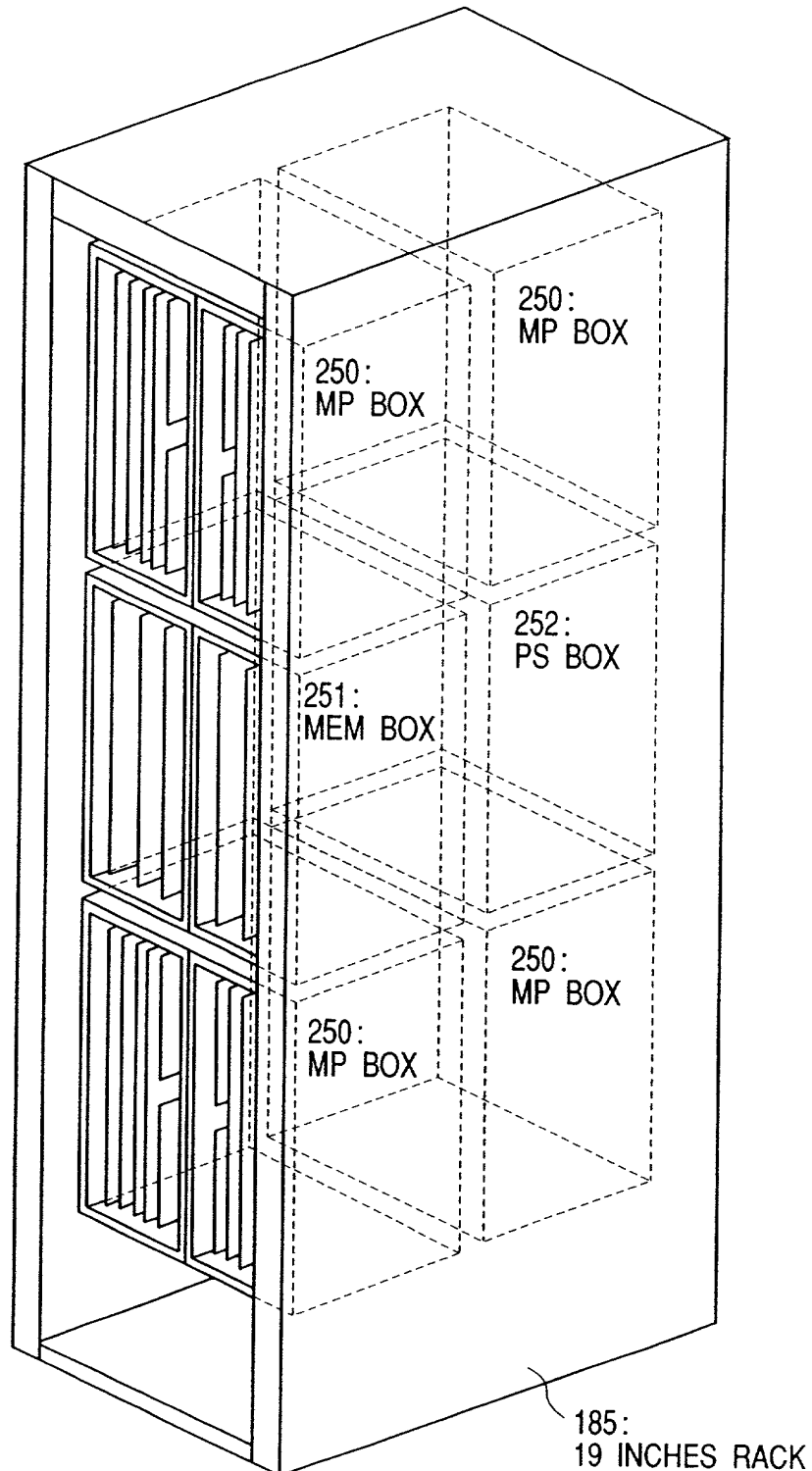
78/83

FIG. 78



79/83

FIG. 79



80/83

FIG. 80

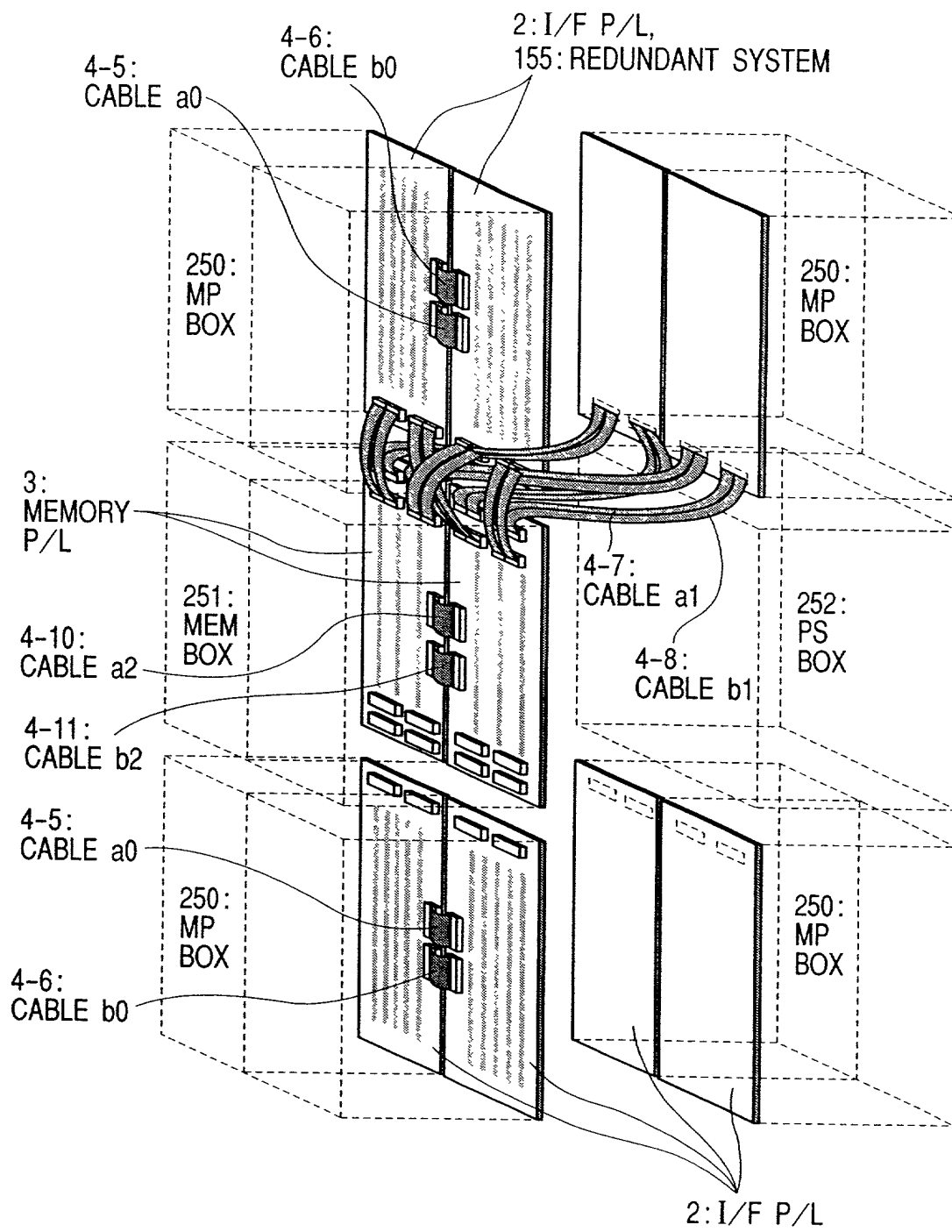


FIG. 81

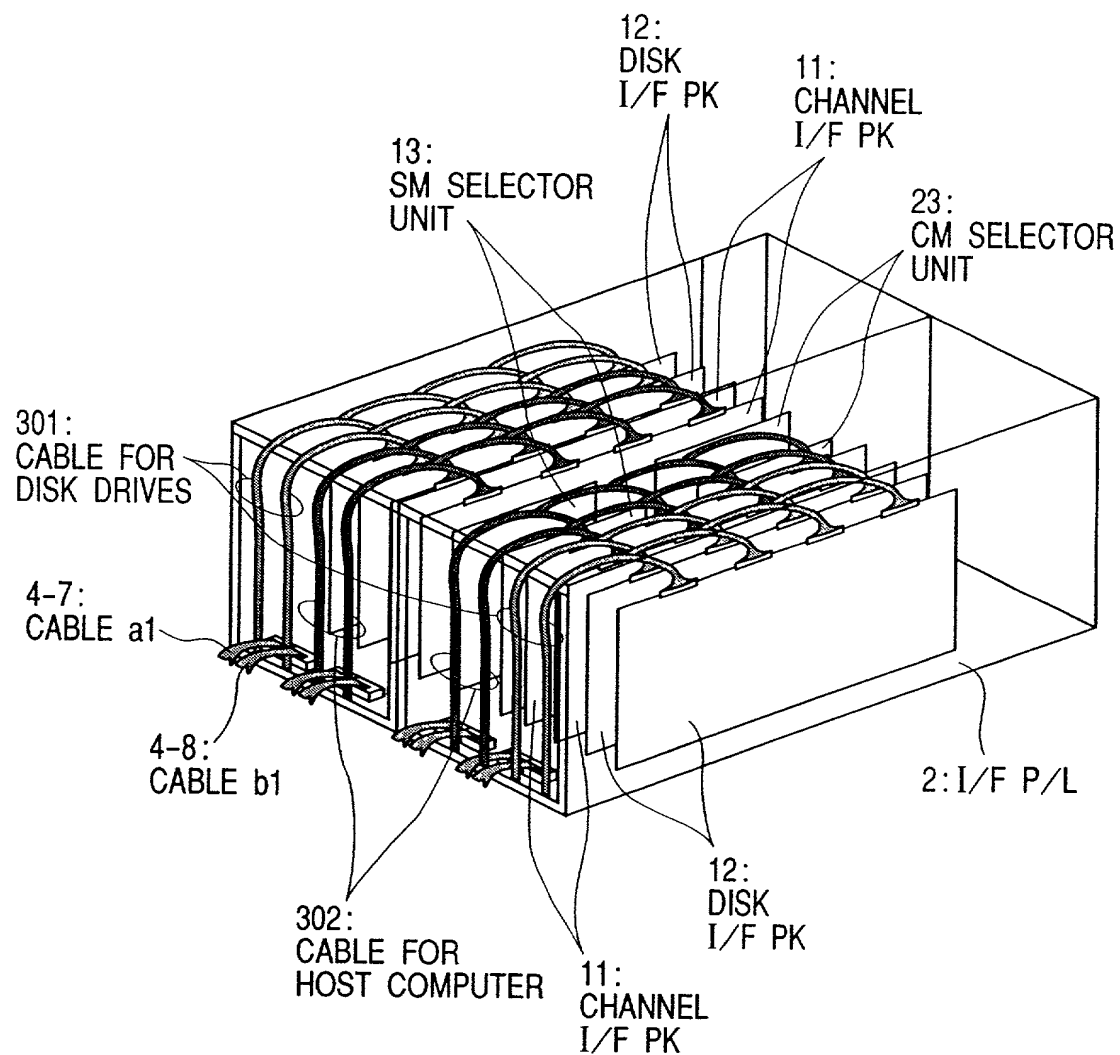


FIG. 82

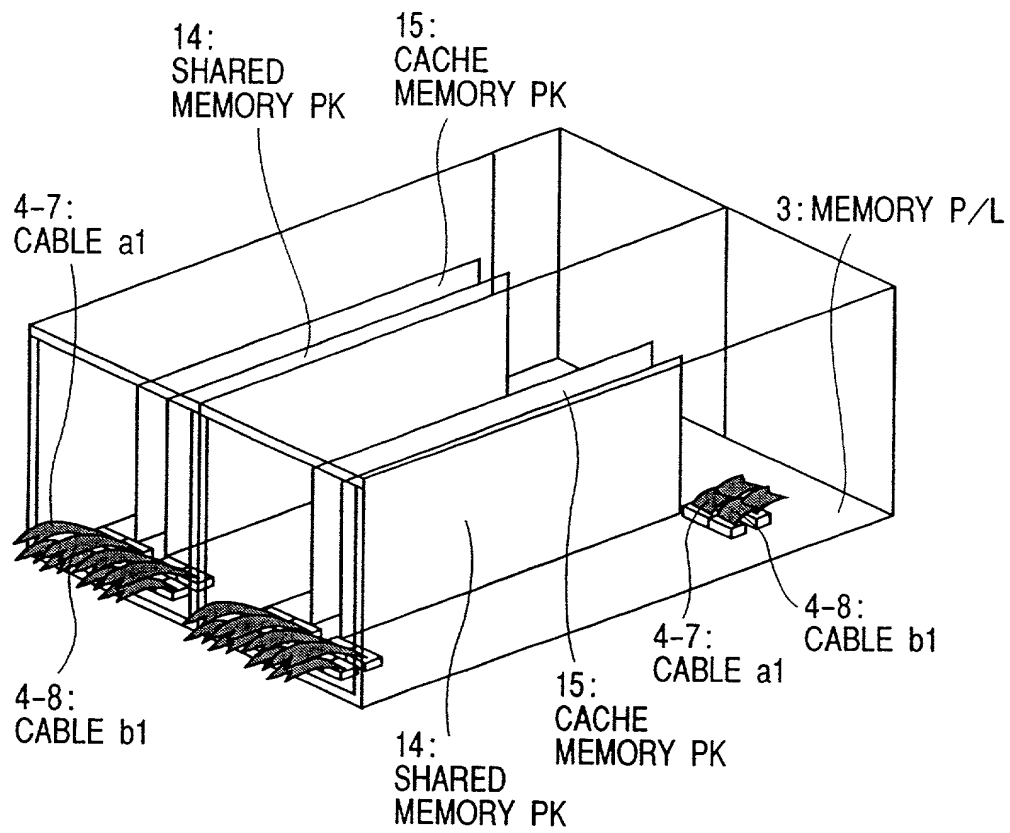
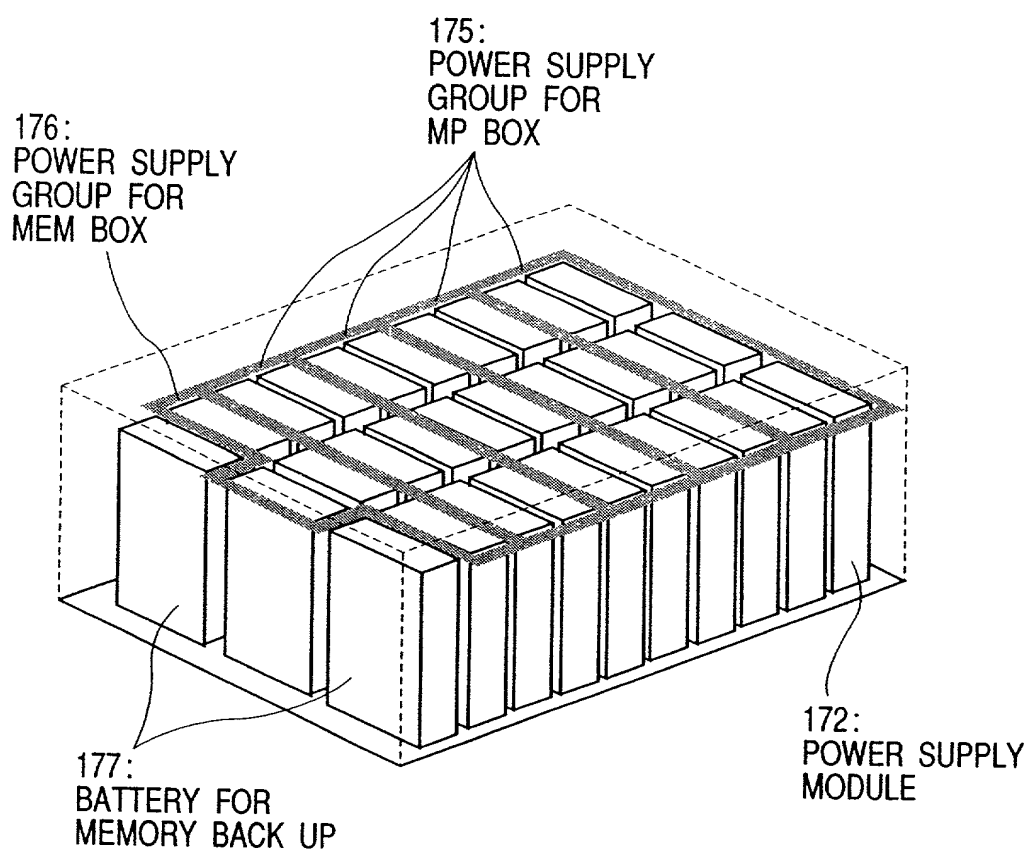


FIG. 83

#3
C. Burf
525 Rec'd PCT/PTO 02 JAN 2001

501.39293X00

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: K. FUJIMOTO, et al
Serial No.: 09/700,874
Filing Date: January 2, 2001
For: DISK ARRAY CONTROLLER
Art Unit: Not yet assigned
Attention: Box Missing Parts

SUBMISSION OF DECLARATION UNDER 37 CFR §1.63

Assistant Commissioner
for Patents
Washington, D.C. 20231

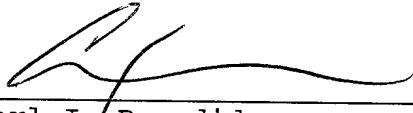
January 2, 2001

Sir:

In the matter of the above-identified application, which was originally filed on November 20, 2000 without a Declaration, and responsive to the Notice to File Missing Parts of Application Filing Date Granted dated December 27, 2000, please find attached hereto a Declaration for submission under 37 CFR §1.63, executed by each of the inventors in the above-identified application.

A Credit Card Payment Form authorizing the requisite \$130.00 fee is attached. Should any additional fees become due in connection with the filing of this Declaration, please charge Deposit Account No. 01-2135 (Case No. 501.39293X00).

Respectfully submitted,



Carl I. Brundidge
Registration No. 29,621
ANTONELLI, TERRY, STOUT & KRAUS, LLP

CIB/jdc
Enclosures
703/312-6600

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

DISK ARRAY CONTROLLER

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を _____ とし、
(該当する場合) _____ に訂正されました。

☒ was filed on May 18, 1998
as United States Application Number or
PCT International Application Number
PCT/JP98/02176 and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条(a)-(d)項又は365条(b)項に基づき下記の、米国外の国の少なくとも一カ国を指定している特許協力条約365(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

Prior Foreign Application(s)

外国での先行出願

(Number) (番号)	(Country) (国名)
(Number) (番号)	(Country) (国名)

私は、第35編米国法典119条(e)項に基づいて下記の米国外の特許出願規定に記載された権利をここに主張いたします。

(Application No.) (出願番号)	(Filing Date) (出願日)
-----------------------------	------------------------

私は、下記の米国法典第35編120条に基づいて下記の米国外の特許出願に記載された権利、又は米国外を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国外の特許出願に開示されていない限り、その先行米国外出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.) (出願番号)	(Filing Date) (出願日)
(Application No.) (出願番号)	(Filing Date) (出願日)

私は、私自身の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じることに基づき表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の表明を行えば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed
優先権主張なし

(Day/Month/Year Filed) (出願年月日)	<input type="checkbox"/>
(Day/Month/Year Filed) (出願年月日)	<input type="checkbox"/>

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)
-----------------------------	------------------------

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)
(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Japanese Language Declaration (日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の
手続きを米特許商標局に対して遂行する弁理士または代理人
として、下記の者を指名いたします。(弁護士、または代理
人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint
the following attorney(s) and/or agent(s) to prosecute this
application and transact all business in the Patent and Trademark
Office connected therewith (*list name and registration number*)

Donald R. Antonelli, Reg. No. 20,296; David T. Terry, Reg. No.
20,178; Melvin Kraus, Reg. No. 22,466; William I. Solomon, Reg.
No. 28,565; Gregory E. Montone, Reg. No. 28,141; Ronald J.
Shore, Reg. No. 28,577; Donald E. Stout, Reg. No. 26,422; Alan E.
Schiavelli, Reg. No. 32,087; James N. Dresser, Reg. No. 22,973
and Carl I. Brundidge, Reg. No. 29,621

書類送付先

Send Correspondence to:

Antonelli, Terry, Stout & Kraus, LLP
Suite 1800
1300 North Seventeenth Street
Arlington, Virginia 22209

直接電話連絡先：(名前及び電話番号)

Direct Telephone Calls to: (*name and telephone number*)

Telephone: (703) 312-6600
Fax: (703) 312-6666

唯一または第一発明者名

Full name of sole or first inventor

Kazuhisa Fujimoto

発明者の署名

日付

Inventor's signature

Date

Kazuhisa Fujimoto

10/5/2000

住所

Residence

Kokubunji, Japan

国籍

Citizenship

Japan

私書箱

Post Office Address

c/o Hitachi, Ltd., Intellectual Property Group
New Marunouchi Bldg. 5-1, Marunouchi 1-chome,
Chiyoda-ku, Tokyo 100-8220, Japan

(第二以降の共同発明者についても同様に記載し、署名をす
ること)

(Supply similar information and signature for second and
subsequent joint inventors.)

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

第二共同発明者名		200 Full name of second joint inventor, if any	
第二共同発明者の署名		Akira FUJIBAYASHI	
住所	日付	Second inventor's signature	Date
		Akira Fujibayashi	11/14/2000
住所		Residence	
		Kodaira, Japan	JPX
国籍		Citizenship	
		Japan	
私書箱		Post Office Address	
		c/o Hitachi, Ltd., Intellectual Property Group	
		New Marunouchi Bldg. 5-1, Marunouchi 1-chome,	
		Chiyoda-ku, Tokyo 100-8220, Japan	
第三共同発明者名		300 Full name of third joint inventor, if any	
第三共同発明者の署名		Nobuyuki MINOWA	
住所	日付	Third inventor's signature	Date
		Nobuyuki Minowa	10/5/2000
住所		Residence	
		Odawara, Japan	JPX
国籍		Citizenship	
		Japan	
私書箱		Post Office Address	
		c/o Hitachi, Ltd., Intellectual Property Group	
		New Marunouchi Bldg. 5-1, Marunouchi 1-chome,	
		Chiyoda-ku, Tokyo 100-8220, Japan	
第四共同発明者名		Full name of fourth joint inventor, if any	
第四共同発明者の署名		Fourth inventor's signature	
住所	日付	Date	
住所		Residence	
国籍		Citizenship	
私書箱		Post Office Address	
第五共同発明者名		Full name of fifth joint inventor, if any	
第五共同発明者の署名		Fifth inventor's signature	
住所	日付	Date	
住所		Residence	
国籍		Citizenship	
私書箱		Post Office Address	